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MUNGER, TOLLES & OLSON LLP

355 SOUTH GRAND AVENUE
THIRTY-FIFTH FLOOR
LOS ANGELES, CALIFORNIA 90071-1560
TELEPHONE (213) 683-9100
FACSIMILE (213) 687-3702

33 NEW MONTGOMERY TOWER
NINETEENTH FLOOR
SAN FRANCISCO, CALIFORNIA 94105-9781
TELEPHONE (415) 512-4000
FACSIMILE (415) 512-4077

WRITER'S DIRECT LINE

213-683-9119
213-683-5119 FAX
taftpr@mto.com

October 15, 1997

Lewis Maldonado, Esq.
ORC-3
U.S. Environmental Protection Agency
75 Hawthorne Street
San Francisco, CA 94105

VIA FEDERAL EXPRESS

Re: BPOU Perchlorate PRPs

Dear Lewis:

Enclosed are several National Archive documents that relate to the disposal practices of perchlorate at Day & Night Manufacturing Company at its Azusa facility during the Second World War. These include:

1. Ordnance Safety Manual No. 7224, dated December 1, 1941, involving regulations governing the manufacture, storage, loading, and handling of military explosives and ammunition at establishments of the Ordnance Department, U.S. Army.

2. War Department Technical Manual No. 9-1900 dated July 3, 1942.

3. War Department Technical Manual No. 9-1900 dated June 18, 1945.

4. War Department Technical Manual No. 9-1904, dated March 2, 1944, entitled Ammunition Inspection Guide.

The Ordnance Department of the U.S. Army maintained tight control over the safe operations of all ordnance establishments. Paragraph 6 of the Ordnance Safety Manual proscribes:

> "The Chief of Ordnance exercises general supervision over the safety of ordnance establishments. He prescribes general and certain special safety regulations to be applied in manufacturing, loading, storing, handling, shipping, and maintaining explosives and ammunition."

Paragraph 6b, provides:

> "The commanding officer of an ordnance establishment is solely responsible to the Chief of Ordnance for the safety of his establishment. He will enforce the mandatory provisions of this manual and will be guided by the advisory provisions."

Paragraph 6c, provides:

> "At each establishment, a safety officer will be appointed by the commanding officer. The safety officer should be the supervisor of safety at the establishment, and is responsible to the commanding officer for the enforcement of all safety regulations and standards, but has no authority to waive or alter any of the provisions of this manual."

The manual contains provisions on the manner in which various explosives are to be destroyed. With respect to pyrotechnics, it states in paragraph 66*l*:

> "Pyrotechnics, except parachute flares and photoflash bombs, will be destroyed by burning in a pit in a manner similar to that proscribed for primers. Parachute flares will be destroyed by burning on the ground in the open. Individual flares should be separated by a distance of at least 4 feet and placed on top of a layer of combustible material. After lighting the train of combustible material, personnel should take cover or withdraw to a safe distance. Photoflash bombs will be destroyed as prescribed in paragraph 66e for artillery shell."

Paragraph 66e states that if no artillery range is available, then:

> "The projectile to be destroyed is placed on its side in the pit and the required number of demolition blocks as prescribed in the following table will be placed in intimate

contact with the side of the projectile and held in position by earth packed around the projectile."

It is then detonated.

The safety manual also proscribes the method for handling the various materials that go into specific ordnance. In Paragraph 153, the safety manual states:

"Photoflash bombs are loaded with flashlight powder, which is similar to black powder as to hazards in handling and storage."

Detailed instructions are given on the handling of black powder. Paragraph 74g provides:

"If black powder is spilled on benches or floors all work will be stopped until the powder has been removed and the explosive hazard of any remaining dust or fine particles has been <u>neutralized with water</u>." Emphasis added.

Paragraph 74h goes on to provide:

"Rooms or buildings in which black powder is handled will be inspected frequently for the presence of black-powder dust; and <u>all such dust will be immediately removed with water</u>." Emphasis added.

In May of 1943 an explosion took place at the Day & Night facility which killed three people including and Ordnance Department inspector. Following a report on the explosion, a recommendation and order was entered with respect to the facility by the Chief of Ordnance on August 21, 1943. The Recommendation described the materials involved in the accident as follows:

"Several drums of waste paper and sweepings, approximately three hundred (300) pounds of rejected photoflash mixed composition (in two 52-gallon drums) were involved. This composition was rejected because the potassium perchlorate had become wet during shipment to the facility, and caused excessive 'balling' in the composition mixing process."

The order of the Chief of Ordnance was:

" Destruction of M 46 Photoflash Bombs should be accomplished by competent personnel in a manner prescribed in Ordnance Safety Manual No. 7224, paragraph 66 e. The loose composition should be destroyed by burning in accordance with paragraph 66 a in quantities of five pounds or less each if practicable.

By order of the Chief of Ordnance:"

Paragraph 66a deals with black powder, whose handling, as noted above, was considered the standard for photoflash powder. This paragraph states:

> "The safest method of destroying black powder is to dump it into a stream or body of water; but if no suitable body of water is convenient, it may be burned. In opening containers, safety tools only will be used. The contents of one container only will be burned at one time. The powder must be removed from the container and spread out on the ground in a trail about 2 inches wide. Care being taken that no part of the trail parallels another part at a distance of less than 10 feet. A train of inflammable material, such as excelsior, should be used to ignite the powder. Emptied containers will be washed out, as serious explosions have occurred with supposedly empty black-powder cans."

A copy of the recommendation and order is attached to this letter.

There are several conclusions that can be drawn from the Ordnance Safety Manual at Day & Night. 1) After August 1943, Day & Night was under direct orders from the United States to burn its waste photoflash materials on the ground. 2) Waste flares were burned on the ground. 3) The appropriate practice for minimizing the constant danger of explosions in the work spaces was to wash the areas down with water. At that time, there was no sewer connection to these properties. As a result, all wash water would have been released on the ground. Based on the 1945 site map that we sent you earlier, it would appear certain that the large mixing areas, bounded by revetments, on the Day & Night property, were regularly washed down with water to avoid the accumulation of perchlorate and the other explosive ingredients for flares and photoflash bombs that could create a safety hazard to personnel.

The burning practices in open pits are consistent with all we know about how Aerojet handled perchlorate. As reflected in the Aerojet 104(e) response, the burn area was regularly washed down with water after a burning both to avoid grass fires and to assure that a later burn did not put new material on top of old embers that could endanger personnel. Moreover, washing down with water was the best method to make sure that unburned material did not accumulate on the burn site. Undoubtedly these practices were similar for both companies.

If you examine the other Technical Memoranda which are enclosed, you will find that they are totally consistent with the Safety Manual on the manner in which flares, photoflash bombs and waste materials were to be handled and/or destroyed. An even more detail description of how black powder was to be burned is found in TM 9-1904 at pages 773-74, and how flares are to be burned on page 775.

Based on materials sent you earlier, Day & Night had a number of rejected flares since the initial product specifications contained defects. Moreover, it is clear the dangers in the workplace to personnel from perchlorate were constant. On April 25, 1945, Day & Night was admonished to engage in better housekeeping "such as the removal of scrap material." I have included the historical report for the third quarter of 1945 which includes the following report after an inspection on July 11, 1945:

> "On 11 July, while T. H. Trask was visiting Day & Night Flare Corp., it was discovered that a very dangerous practice was being followed in their pressroom. Excessive amounts of waste powder were being accumulated and minor detonations were occurring when the molds were struck with a metal tool to knock the center plugs back into position after the ejection operation."

On July 17th, conditions were improved "but even so housekeeping and maintenance were found to be very poor." The same quarterly history refers to the fact that several hundred pounds of waste flare composition and waste flares had been accumulated, all of which were then destroyed by Day & Night. At the end of August 1945, the company had 20,000 rejected aircraft signals to be destroyed. T. H. Trask is reported as saying: "It is expected that this material will be disposed of together with the termination inventories of hazardous material at Day & Night." We have to presume, Day & Night followed the safety manual and the directions of the Chief of Ordnance.

It is thus apparent that the disposal of materials and the requirement to keep facilities clean contributed resulted in a very substantial amount of perchlorate being either washed down at the plant and flushed to the ground or burned in the Kincaid Pit.

Based on the foregoing, it is apparent that Day & Night was a large contributor of perchlorate to the soil and ultimately the groundwater at the Kincaid Pit and at its facilities. This is clear evidence of "spills." It is also clear that the method of disposal was ordered by the United States.

Any contingent liabilities of Day & Night were clearly assumed by both United Technologies and Dresser Industries. As noted in prior letters, Dresser acquired Day & Night in April 1945 and the assets of Day & Night's continuing business, including its defense business, were later acquired by Carrier. The remaining net worth and contingent liabilities of Day & Night were dissolved into Dresser Industries.

One final argument which I made to you over the phone relates to your concern that there was no evidence of a "spill" by Day & Night. We obviously disagree, especially with the new evidence established by the safety manual. Nonetheless, in selecting prior PRPs, EPA did not require that it be shown that successive owners of a contaminated site each be shown to have a proven spill before being named as a PRP. It has been enough that they all are shown to have used the chemical. Thus, at the Valspar site, EPA has named Mobil, Valspar and Martin Marietta even though, to my knowledge, spills were not shown by each PRP.

While we have not yet come up with your eye witness, we believe we have provided sufficient evidence to name Day & Night and its successors as PRPs.

Sincerely,

Peter R. Taft

PRT:mlp
Enclosure

LC PB# 5209

3259

*TM 9-1900

TECHNICAL MANUAL }
No. 9-1900 }

WAR DEPARTMENT,
WASHINGTON, July 3, 1942.

AMMUNITION, GENERAL

*This manual supersedes TM 9-1900, September 8, 1941, including Training Circulars Nos. 11 and 12, War Department, 1942.

CHAPTER 1

GENERAL

SECTION I

INTRODUCTION

1. Purpose.—*a.* This manual is published for the information and guidance of all Army personnel having to do with ammunition. Those responsible for the handling of ammunition should become thoroughly familiar with its provisions.

b. The requirements of this manual are applicable to all Army posts, camps, and other stations, except ordnance establishments under the direct control of the Chief of Ordnance, where the requirements of the Ordnance Safety Manual (O. O. Form 7224) will govern.

2. Scope.—The information contained herein is of a general technical nature. It concerns the several types of ammunition, their general characteristics, means of identification, care in handling and use, storage and maintenance, surveillance and grading, packing and marking, shipping, and the destruction of duds and unserviceable ammunition. Further information concerning specific types of ammunition is contained in Technical Manuals and Field Manuals dealing with the weapon in which the ammunition is used, or, in the case of ammunition such as bombs and grenades which do not require a weapon, this information is contained in Technical Manuals pertaining to these types.

3. References.—Publications containing additional information, referred to in the text, and other pertinent references are included in appendix III.

SECTION II

GENERAL DISCUSSION

4. General.—*a.* The term "ammunition" as used herein, unless otherwise limited, will be understood to include all military ammunition and components thereof. It applies to missiles dropped or thrown by hand, and pyrotechnics, as well as projectiles propelled by a charge of powder.

b. Depending upon its general characteristics and methods of use, ammunition is grouped into the following basic types:

(1) Small-arms ammunition—cartridges and shotgun shells used in small-arms weapons.

(2) Grenades—explosive and chemical missiles thrown by hand or projected by rifles, guns, or special projectors.

(3) Antitank mines—explosive mines usually laid in advance positions as protection against mechanized attack.

(4) Mortar ammunition—explosive and chemical ammunition used in mortars commonly known as trench mortars.

(5) Artillery ammunition—explosive and chemical ammunition used in cannon of all calibers.

(6) Bombs—explosive and chemical missiles designed for release from aircraft.

(7) Pyrotechnics—ammunition designed to produce brilliant or colored lights for illumination or signaling.

5. Nomenclature.—Standard nomenclature is established in order that each of many items supplied by the Ordnance Department may be specifically indentified by name. These names are published in Standard Nomenclature Lists (SNL's). The nomenclature for ammunition items is published in SNL groups P, R, S, and T. For all purposes of record, the use of this nomenclature is mandatory. Standard nomenclature is used herein in all references to specific items of issue. Examples of representative nomenclature are—

Cartridge, ball, caliber .30, M2.

Shell, fixed, HE, M41, with fuze, PD, M48, 75-mm gun.

Shell, semifixed, HE, M41, with fuze, PD, M48, 75-mm pack howitzer M1 and M1A1.

Shell, HE, M102, unfuzed, 155-mm howitzer (adapted for fuze, PD, M51 or M55, with booster M21).

Charge, propelling, M1 (green bag), 155-mm howitzer M1917-18.

Bomb, demolition, 100-pound, M30, unfuzed (adapted for nose fuze M103 and tail fuze M100 or M106).

6. Classification.—*a.* Ammunition is classified according to use as service, practice, blank, or drill. Ammunition may also be classified according to the kind of filler, as explosive, chemical, or inert.

b. Service ammunition is that which is used for effect. Such ammunition (expect small-arms ammunition) usually has a high explosive or chemical filler.

c. Practice ammunition is provided for training in marksmanship. This type may have a small quantity of low explosive filler to serve as a spotting charge, or the filler may be inert.

d. Blank ammunition is provided for saluting purposes and for simulated fire. It has no projectile.

e. Drill or dummy ammunition is used for training in handling and loading (service of the piece), and similar purposes. It is completely inert.

7. Identification.—*a. General.*—Every item of ammunition is completely indentified by the painting, marking (which includes the ammunition lot number), and accompanying data cards or tags. For purposes of record the standard nomenclature of the item, together with its lot number, completely identifies the ammunition. Included in both the marking and the standard nomenclature are—

(1) A brief description of the type or suitable abbreviation thereof.

(2) Caliber, weight, or size.

(3) Model designation.

(4) Where required, such additional information as the model and type of fuze, the model of the cannon in which the item is fired, the weight of projectile for which a separate loading propelling charge is suited, etc.

(5) The lot number is marked on the ammunition but is not a part of the nomenclature. However, when referring to specific ammunition, it is necessary to mention the lot number as well as the standard nomenclature.

b. Model.—To distinguish a particular design, a model designation is assigned at the time the model is classified as an adopted type. This model designation becomes an essential part of the standard nomenclature and is included in the marking on the item. Prior to the World War, the year in which the design was adopted, preceded by an M, was used as the model designation, for example, M1906. From the World War until July 1, 1925, it was the practice to assign mark numbers. The word "Mark," abbreviated "Mk.," was followed by a roman numeral, for example, shell, HE, Mk. III. The first modification of a model was indicated by the addition of MI to the mark number, the second by MII, etc. The present system of model designation consists of the letter M followed by an arabic numeral. Modifications are indicated by adding the letter A and appropriate arabic numerals. Thus M2A1 indicates the first modification of an item for which the original model designation was M2. Certain items standardized for use by both Army and Navy are designated by the letters AN preceding the model designation, for example, AN-M100A1, AN-Mk. 19.

c. Ammunition lot number.—When ammunition is manufactured an ammunition lot number, which becomes an essential part of the marking, is assigned in accordance with pertinent specifications. This lot number is stamped or marked on every item of ammunition unless the item is too small, on all packing containers, and on the accompanying ammunition data card or tag. It is required for all purposes of record, including reports on condition, functioning, and accidents in which the ammunition is involved. To provide for the most uniform functioning, all of the components in any one lot are manufactured under as nearly identical conditions as practicable. For example, in the case of fixed ammunition, all of the rounds in any one lot consist of—

(1) Projectiles of one lot number (one type and one weight zone).

(2) Fuzes of one lot number.

(3) Primers of one lot number.

(4) Propellent powder of one lot number.

d. Ammunition data card.—A 5- by 8-inch card printed with pertinent information and data concerning the item and its components, known as an ammunition data card, is packed in each packing box with the ammunition or, in the case of bundle packing, in each fiber container. When required, assembling and firing instructions are printed on the reverse side of the card. On recent shipments, the data cards are not packed with the ammunition and only a limited quantity are forwarded with the shipping tickets.

8. Painting and marking.—*a. Painting.*—Ammunition is painted to prevent rust and to provide, by means of color, a ready means of identification as to type. The color scheme is as follows:

(1) For other than bombs and small-arms ammunition:

Type	*Base color*	*Marking*
High explosive	Yellow	Black
Low explosive	Red	Black
Chemical	Gray	Green, red, yellow, or purple, according to kind of filler
Practice	Blue	White
Dummy (inert)	Black	White

(2) For bombs, the color scheme has been the same as above. A new color scheme has been adopted and bombs of recent manufacture and those to be stored in the open (except chemical bombs) will be painted olive drab, lusterless, with 1-inch colored bands appearing at the nose and tail ends of the body and a ¼-inch interrupted band at the center of gravity. The color of the bands will be as follows:

Bombs containing a high-explosive filler (demolition, general purpose, fragmentation)	Yellow
Practice	Blue
Drill or inert	Black

Chemical bombs will be painted gray and marked in accordance with the old color scheme.

(3) For small-arms ammunition, cartridges do not require painting. The packing boxes, however, are painted brown with marking in yellow, and have a distinctive color band, as follows:

Type	*Band*
Ball	Red
Blank	Blue
Dummy	Green
Guard	Orange
Gallery practice	Brown
High-pressure test	Yellow
Tracer	Green on yellow
Armor-piercing	Blue on yellow
Ball and tracer	Yellow, red, green (3 stripe band)

b. Marking.—The marking stenciled or stamped on the ammunition and on its packing containers includes all information necessary for complete identification. Further information concerning painting and marking will be found under the specific type in chapter 2 and in section IV, chapter 3.

9. Grading.—*a.* Ammunition is manufactured to rigorous specifications and thoroughly inspected and tested before acceptance.

In accordance with the results of these tests, each lot of ammunition is assigned a grade. Ammunition in storage is periodically retested to insure that its characteristics have not changed. If changes have occurred, the ammunition is regraded.

b. Each lot of small-arms ammunition is graded primarily on the qualities which make that lot especially suitable for use in a particular class of small-arms weapons. See Ordnance Field Service Bulletin No. 3-5.

c. Each lot of ammunition other than small-arms is graded as a result of surveillance tests. See Ordnance Field Service Bulletin No. 3-1.

10. Priority of issue.—*a.* Subject to special instructions from the Chief of Ordnance, ammunition of appropriate type and model will be used in the following order: limited standard, substitute standard, standard. Within this rule, ammunition which has had the longest or least favorable storage will be used first. Among lots of equal age, priority will be given to the smallest lot.

b. To prevent the building up of excess stocks in the field, transfers may be arranged within the corps area if no stock of appropriate grade for immediate use is on hand.

c. Priority of issue for lots of small-arms ammunition is established by the Chief of Ordnance and published in Ordnance Field Service Bulletin No. 3-5, or in special instructions.

d. Further details will be found in the Ordnance Field Service Bulletins, Series 3, and in AR 775-10.

11. Care and preservation.—*a.* In order to keep ammunition in a serviceable condition, ready for immediate issue and use, due consideration should be given to the following:

b. Ammunition should be stored in the original containers, in a dry, well-ventilated place, protected against the direct rays of the sun and other sources of excessive heat.

c. Ammunition and its containers should be kept clean and dry and protected from damage.

d. Components of ammunition should not be disassembled without specific authorization.

e. Sealed containers should not be opened nor protective or safety devices removed until just before use.

f. Ammunition prepared for firing but not fired should be returned to its original packing and appropriately marked. Such ammunition should be used first in subsequent firings in order that stocks of opened packings may be kept at a minimum.

12. Packing and marking for shipment.—*a.* Ammunition is packed and marked in accordance with pertinent specifications and drawings.

b. Packings for ammunition are designed to withstand all conditions ordinarily encountered in handling, storage, and transportation and to comply with Interstate Commerce Commission regulations.

c. Marking includes all information required—

(1) *For complete identification of contents.*

(2) By the Interstate Commerce Commission for shipping, including addresses of consignor and consignee and shipping designation of the contents.

d. Further information concerning packing and marking is contained in section IV, chapter 2.

Section III

PROPELLANTS

13. General.—Explosives of one kind or another are a fundamental part of all ammunition. For military purposes, explosives are divided into two basic groups, propellants and high explosives. One of the chief differences between these groups is the rapidity with which the explosion occurs. Propellants explode at a relatively slower rate than high explosives. High explosives detonate almost instantaneously. Propellants comprise those explosives which are used principally for propelling projectiles from guns. They are described in this section. High explosives comprise those used principally as filler or bursting charge for explosive components such as projectiles, bombs, and grenades, and also those used as initiators. They are described in section IV. Further information concerning properties, methods of manufacture, etc., will be found in TM 9-2900.

14. Explosive train.—A series of explosives beginning with a small amount of sensitive explosive and terminating with a large amount of comparatively insensitive explosive is termed an explosive train. In general there are two such trains, the propelling charge explosive train and the bursting charge explosive train. The propelling charge explosive train usually consists of primer, igniter or

igniting charge, and propelling charge. Thus a spit of fire from a small quantity of sensitive explosive (the primer) is transmitted and intensified (by igniter) to the end that a large quantity of relatively insensitive explosive (the propelling charge) burns in the manner required to project the projectile properly. In some instances, such as small-arms cartridges, where the propelling charge is relatively small, the igniter is not required. The bursting charge explosive train is described in section IV.

15. Classification.—All explosives currently used as propellants have a nitrocellulose base and are commonly known as smokeless powders. Various organic or inorganic substances are added to the nitrocellulose base during manufacture to give improved qualities for special purposes. These powders are distinguished by such terms as double-base powder; flashless-nonhygroscopic, FNH; and nonhygroscopic, NH; as well as commercial trade names or symbols. A straight nitrocellulose powder is known as pyro powder. Black powder as a propellant has been almost completely superseded by smokeless powder.

16. Smokeless powder.—*a. Characteristics.*—Smokeless powder is not entirely smokeless and it is not a powder. It is manufactured in the form of flakes, strips, pellets, or perforated cylindrical grains. The cylindrical grains are made with varying diameters and lengths. The critical dimension is the web size, that is, the average thickness of the powder between the perforations. In color, the grains vary from a light amber to a deep brown or black. Figure 1 illustrates typical grains. Strip powder may be used as a satisfactory substitute for perforated cylindrical grains in time of emergency.

b. Burning action.—Unconfined smokeless powder burns like celluloid with little ash or smoke, but when confined its rate of burning increases with temperature and pressure. Figure 2 shows the manner in which the grains burn.

c. Solvent.—Smokeless powder is manufactured to contain in the finished grains a definite amount of solvent (an ether and alcohol mixture). If there is a marked change in the amount of solvent, a change in ballistic properties will result. Powder must be carefully protected against high temperatures, moisture, and changes in temperature. To guard against changes due to such conditions, smokeless powder is always packed in airtight containers.

d. Use.—Nitrocellulose smokeless powder is used as the propellant for small-arms and larger caliber ammunition. The perforated form of grain is the one most commonly used in United States military powders. Single perforated grains are used for small arms, minor caliber cannon, and certain howitzers. Powders with seven perforations are used for larger caliber weapons. See figure 3 for examples.

17. Pyro powder (straight nitrocellulose powder).—For many years the standard powders in service were of the straight nitrocellulose type. Commonly referred to as pyro powder or pyrocellulose, it is now largely used as a substitute standard for the FNH and NH powders. A disadvantage is the production of muzzle flash in firing. It is also hygroscopic and has relatively low potential.

18. Double-base powder.—The term double-base powder has been applied to powders containing both nitrocellulose and nitroglycerin, the nitroglycerin serving to increase the potential. Small percentages of inorganic salts are often added, serving to reduce flash and make the powder more ignitible. Ballistite is a typical nitroglycerin powder and is used in 12-gage shotgun shell and in 3-inch mortar ammunition.

19. FNH and NH powder.—Flashless-nonhygroscopic (FNH) powders are mixtures of nitrocellulose and other materials which are added in order to cool the products of combustion, thereby reducing the flash. These added materials also reduce hygroscopicity, that is, tendency to absorb moisture. They are used in propellants for most guns and howitzers of 37-mm and larger caliber. FNH powder may be flashless in one weapon and yet not completely flashless in another. When FNH powder is designated to be used with weapons in which flash occurs, it is termed NH powder. Nitroglycerin is used in certain FNH powders for small cannon, in trench mortar propellants where especially rapid burning is required, and in certain high velocity ammunition.

20. Guncotton.—Guncotton, a nitrocellulose of high nitration, is used in the manufacture of FNH powders. Small wisps of dry guncotton are used as flame carriers in the central tube of shrapnel to connect the fuze with the base charge. It is also used in electric primers.

21. E. C. smokeless powder.—E. C. smokeless powder, or E. C. blank fire, consists of nitrocellulose with inorganic nitrates. It is usually orange or pink in color and resembles coarse sand, though it is soft and light. It is sensitive to friction, shock, or heat. It absorbs moisture readily and so must be protected from the atmosphere. It is usually exploded by flame from a primer or fuze. It burns extremely rapidly in the open, but explodes if confined. It is used as a bursting charge in fragmentation hand grenades. It is also used in caliber .30 and caliber .50 blank cartridges.

22. Small-arms propellants.—Smokeless powder for small arms differs from that used for cannon in that it is usually glazed with graphite to facilitate machine loading and thus presents a black polished appearance. Since the powder grains are small, they ignite more readily and burn more freely than cannon powder; and when moisture is present or abnormal temperature prevails, they are subject to more rapid deterioration than the larger grains. Small-arms powders, like cannon powders, are packed in airtight containers. Many small-arms powders are nearly as sensitive as black powder to friction. Therefore, all precautions used in handling black powder should be observed for small-arms powders. In general, there are two types of small-arms propellants, the single-base pyrocellulose type and the double-base type.

23. Black powder.—*a. General characteristics.*—Black powder is an intimate mechanical mixture of finely pulverized potassium or sodium nitrate, charcoal, and sulfur. The commercial blasting powder with sodium nitrate is now used for saluting charges. Potassium nitrate is used in the powders for all other military purposes. Black powder is usually in the form of small black grains which are polished by glazing with graphite. It is subject to rapid deterioration in the presence of moisture, but if kept dry retains its explosive properties indefinitely. It is one of the most dangerous explosives to handle because it is so easily ignited by heat, friction, or spark.

b. Uses.—As a propellant, black powder has been superseded almost entirely by smokeless powder. Its present military use, in its several grades, is practically confined to—

(1) Ignition charges.

(2) Base charges, or expelling charges, for shrapnel.

(3) Pellets for primers and fuzes.

(4) Blank ammunition charges.

(5) Smoke-puff charges.

(6) Bursting charges for practice bombs, shell, and subcaliber shell.

(7) Time-train rings and combination fuzes.

c. Precautions.—Black powder is particularly sensitive to flame or spark. When handling black powder in cans or bags or when it is not absolutely protected against sparks, the precautions described in section I, chapter 3, will be strictly observed.

Section IV

HIGH EXPLOSIVES

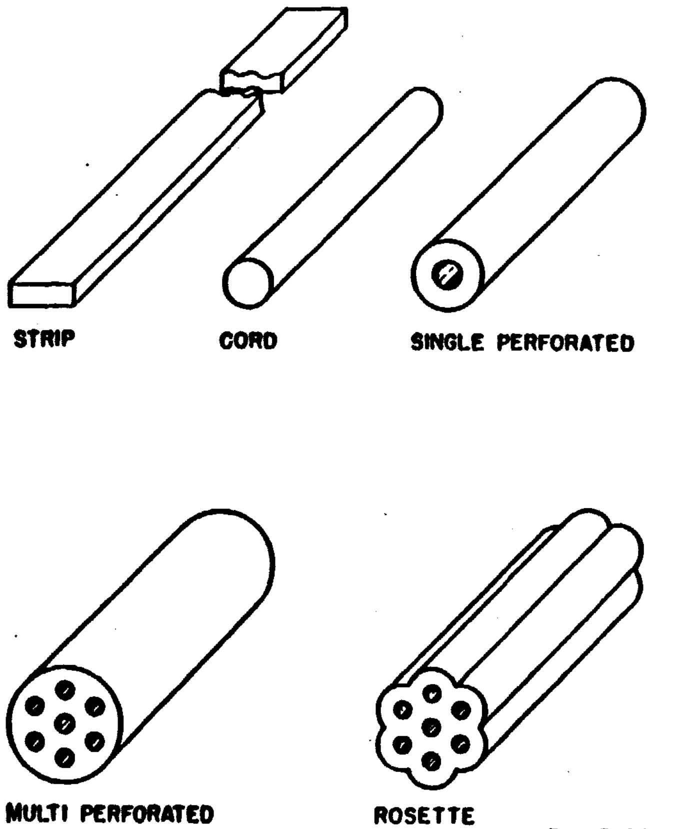


FIGURE 1.—Types of powder grains.

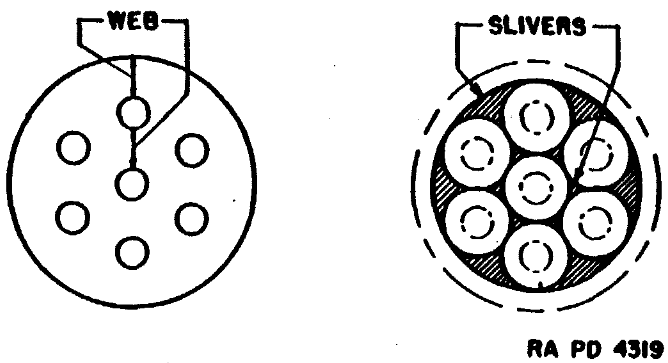


FIGURE 2.—Burning of powder grains.

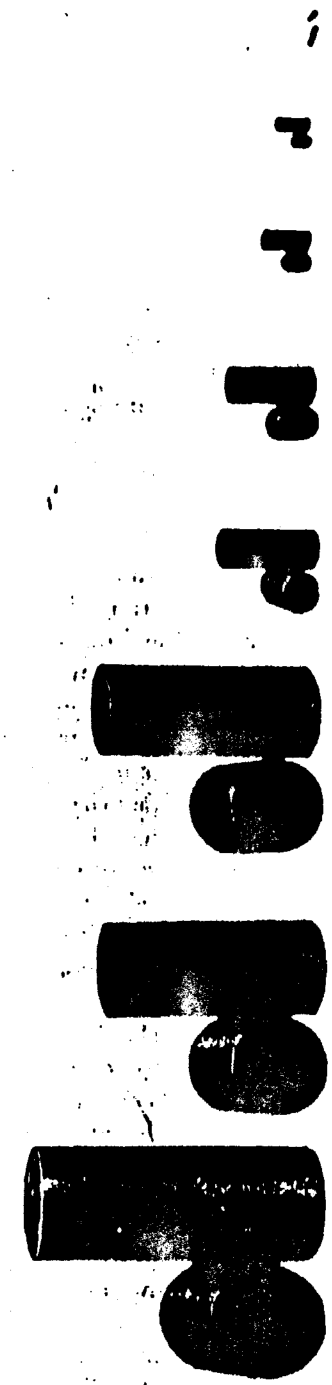


FIGURE 3.—Side and end views of typical powder grains (approximately half size).

24. General.—Those explosives whose rate of decomposition is so high as to preclude their use as propellants and which bring about a powerful disruptive action are known as detonating explosives or, more commonly, high explosives. They are usually nitration products of organic substances such as cellulose, starch, or coal tar derivatives but may be nitrogen-containing inorganic substances or mixtures of both.

25. Explosive train.—Although there are two explosive trains—the propelling-charge explosive train and the bursting-charge explosive train—the term "explosive train" as commonly used is intended to mean bursting-charge explosive train. It consists of a series of explosive elements so designed and arranged that each element successively transmits and intensifies the initial fire from the primer to the end that the relatively large quantity of bursting charge detonates in the desired manner. These elements are usually a primer, time or delay element where required, detonator, booster, and bursting charge, arranged in order of sensitivity—a small quantity of sensitive explosive to a large quantity of less sensitive explosive. The time or delay elements may be omitted when "superquick" action is required, or either or both may be combined in a fuze, with superquick action and means provided for setting the fuze just before use. In chemical ammunition, the bursting charge is replaced by a chemical agent, and the explosive element (which resembles a booster) is called the "burster." The propelling-charge explosive train is described in section III.

26. Trinitrotoluene (TNT).—*a. General.*—Trinitrotoluene, commonly known as TNT, is the principal constituent of many explosives, and has been used by itself under such names as triton, trotyl, tolite, trilite, trinol, tritolo. It is the Army's most important high explosive.

b. Characteristics.—TNT is one of the most stable of high explosives, and can be stored over long periods of time when properly purified. It is relatively insensitive to blows or friction. When ignited by flame in the open it burns rapidly without explosion. Burning or rapid heating of large quantities, especially in closed vessels, may, however, cause violent detonation. It has powerful brisant properties. It is readily detonated by mercury fulminate, tetryl, and other similar high explosives. It is nonhygroscopic and does not form sensitive compounds with metal. It usually resembles light brown sugar but when pure is crystalline and has a very pale straw color. It is a very satisfactory military explosive because it is easily melted and poured into a shell or bomb to form a solid crystalline explosive charge. Ammunition loaded with TNT can be stored, handled, and shipped with comparative safety.

c. Exudation.—Some ammunition loaded with TNT when stored in warm climates or during warm summer months may exude an oily brown liquid. This exudate oozes out around the threads at the nose of the shell, and may form a pool on the floor. Exuding shell should be reported to the corps area or department ordnance officer, who will give the necessary instruction for their use or disposition. The exudate is inflammable and may carry small particles of TNT. Pools of exudate should be removed by scrubbing the floor with hot water.

d. Detonation.—TNT in crystalline form detonates readily under the influence of a No. 6 detonator and, when highly compressed, of a No. 8 detonator. When cast, it is necessary to use a booster charge of pressed tetryl, or an explosive of equal brisance, to insure complete detonation.

e. Use.—(1) *Bursting charge.*—TNT is used as a bursting charge for high explosive shell, alone or mixed with ammonium nitrate to form 50/50 or 80/20 amatol. Flake TNT is used in 37-mm shell. Other military uses of TNT are as a bursting charge for bombs, antitank mines, for parts of certain shell and bomb boosters, and as a constituent of propellent powder.

(2) *Demolition.*—TNT is used to demolish bridges, railroads, and other structures and for land mines placed under enemy trenches or fortifications. For such work TNT is made up in the form of a small, highly compressed block enclosed in a fiber container which protects it from crumbling in handling and renders it waterproof. The triton blocks used by the Corps of Engineers are blocks of pressed TNT, enclosed in a cardboard container.

(3) *Blasting.*—It is suitable for all types of blasting where 40 percent dynamite is used.

(4) *Detonating fuze.*—Primacord Bickford is the trade name for a detonating fuze which consists of a flexible fabric tube filled with high explosive.

27. Amatol.—*a. General characteristics.*—Amatol, a mechanical mixture of ammonium nitrate and TNT, has approximately the same general characteristics as TNT. It is crystalline and yellow or brownish, moisture-absorbing, insensitive to friction, but may be detonated by severe impact. It is readily detonated by mercury fulminate and other high explosives. It has no tendency to form dangerous compounds with metals, except copper and tin, and is less likely to exude than is TNT. It absorbs moisture and corrodes booster casings and threads when moist. Amatol, 50/50, has approximately the same rate of detonation and brisance as TNT. Amatol, 80/20, produces a white smoke on detonation; and amatol, 50/50, a smoke less black than straight TNT.

b. Composition and form.—Amatol, 50/50, consists of 50 percent, by weight, ammonium nitrate and 50 percent TNT; it is sufficiently fluid when hot to be poured or cast like TNT. Amatol, 80/20, consists of 80 percent ammonium nitrate and 20 percent TNT. It resembles wet brown sugar and when hot is a plastic material and is so pressed into shells and bombs.

c. Use.—Amatol is a substitute for TNT. Amatol, 50/50, is used for shell of 3-inch caliber and larger and 80/20 amatol for shell of 155-mm and larger. Amatol is also used in large bombs.

28. Ammonium picrate (explosive D).—*a. Characteristics.*—Ammonium picrate is the least sensitive of military explosives to shock and friction, which makes it well suited for use as a bursting charge in armor-piercing projectiles. It is slightly inferior in explosive strength to TNT. It does not melt but decomposes when heated and explodes. It reacts with metals slowly and when wet it can form sensitive and dangerous picrates with copper and lead. It is difficult to detonate but burns readily like tar or resin.

b. Special precautions.—(1) Ammonium picrate which has been pressed at a shell-loading plant and removed from a shell is very much more sensitive to shock or a blow than new material. It should be protected against shock or fire, and it should preferably be stored in a building by itself.

(2) Although less sensitive than TNT, it can be exploded by severe shock or friction, is highly inflammable, and when heated to a high temperature may detonate.

c. Use.—Explosive D is used as a bursting charge for all armor-piercing shell, in projectiles for seacoast cannon, and in other types of projectiles which must withstand severe shocks and stresses before detonating.

29. Picric acid (trinitrophenol).—*a. Characteristics.*—Picric acid is a lemon-yellow crystalline solid. It is entirely stable, but

the presence of any trace of explosives which detonate more readily, such as metallic picrates, may cause sudden detonation of burning picric acid. It has about the same sensitivity to shock as TNT and is somewhat more readily detonated by means of a detonator. It is one of the most powerful military explosives.

b. Use.—Introduction of TNT as a military explosive has resulted in a gradual abandonment of the use of picric acid. It is used for conversion into ammonium picrate, as a booster explosive, and even as a substitute for part of the mercury fulminate charge in detonators. Picric acid has been used extensively in the form of mixtures with other nitro compounds.

30. Nitrostarch explosives.—*a. General.*—(1) Nitrostarch is a white, finely divided material similar in appearance to ordinary powdered starch. It is more sensitive to impact than TNT but less sensitive than dry guncotton or nitroglycerin. It is highly inflammable, being readily ignited by the slightest spark such as may result from friction, and it burns with explosive violence.

(2) Nitrostarch explosives are readily detonated by mercury fulminate detonators, a No. 6 detonator producing complete detonation unless the explosive has been rendered unduly insensitive by excessive absorption of moisture or by other cause.

(3) A nitrostarch demolition explosive has recently been adopted as a substitute for TNT. It is consolidated into ½-pound and 1-pound (four ¼-pound) blocks and in comparison tests it has been found that the TNT formulas for computing small charges are directly applicable to the nitrostarch demolition explosive. Nitrostarch blocks must not be broken into fragments as this may cause detonation.

b. Use.—Nitrostarch may be considered as a substitute for TNT in emergencies when there is a shortage of toluene for making TNT. During the World War, nitrostarch was used in the following form:

(1) Trojan grenade explosive.
(2) Trojan trench mortar shell explosive.
(3) Grenite.

31. Tetryl.—*a. General.*—Tetryl is the standard booster explosive. It is a yellow crystalline solid. When heated it first melts and then decomposes and explodes. It burns readily and is more easily detonated than TNT or ammonium picrate, being about as sensitive as picric acid. It is detonated by friction, shock, or spark. It is practically nonhygroscopic. It is stable at all temperatures which may be encountered in storage.

b. Detonation.—Brisance tests show tetryl to have greater shattering ability than any other military high explosive. Picric acid and TNT come second and third in brisance, respectively.

c. Use.—(1) *Charges.*—Tetryl is sufficiently insensitive when compressed into a booster to be safely used as a booster explosive. The violence of its detonation insures a high order of detonation of the bursting charge. It is used in the form of pressed pellets. Tetryl has been approved as the standard bursting charge for small-caliber projectiles. It gives appreciably better fragmentation to these shell than TNT. It is also more readily detonated and yet, in small-caliber shell, withstands the force of set-back.

(2) *Detonator.*—Tetryl is also used in detonators as a base charge, the tetryl being pressed into the bottom of the detonator shell and then covered with a small priming charge of mercury fulminate, lead azide, or other initiator.

32. Mercury fulminate.—*a. General.*—Mercury fulminate is a heavy crystalline solid, white when pure but ordinarily a faint brownish yellow or grayish tint. It is extremely sensitive to heat, friction, spark, flame, or shock, detonating completely in nearly every instance. Its sensitivity varies with temperature.

b. Use.—Mercury fulminate is used only for the purpose of bringing about the detonation of the less sensitive high explosives or the ignition of propellent explosives. It may be used alone or mixed with potassium chlorate.

33. Lead azide.—Lead azide is an initiating compound used for bringing about detonation of high explosives. It is a fine cream-colored compound. It is sensitive to flame but is too insensitive to be used alone where initiation is by impact of a firing pin. It is not easily decomposed by heat. It flashes at a much higher temperature than mercury fulminate. Less weight of lead azide than of mercury fulminate is required to detonate an equal amount of TNT, tetryl, etc. Lead azide has been introduced to supersede mercury fulminate.

34. Miscellaneous explosives.—*a. Trimonite.*—Trimonite is a mixture of picric acid and mononitronaphthalene. It may be used as a substitute for TNT in shell wherever amatol may also be used as a substitute.

b. Ammonal.—Ammonal is a high-explosive filler for shell. It is composed of TNT, ammonium nitrate, and flaked aluminum. The term ammonal refers generally to explosive mixtures containing TNT and powdered aluminum. As a rule, ammonal explosives are insensitive and, because of the aluminum content, detonate with resultant higher temperature and brighter flash than other high explosives. They are used in proving ground tests for better observation.

SECTION V

CHEMICAL AGENTS

35. General.—*a. Definition.*—A chemical agent is a substance which, by its ordinary and direct chemical action and in concentrations attainable in the field, produces a toxic or an irritating (harassing) physiological effect, a screening smoke, an incendiary action, or any combination of these. An agent that produces more than one of these effects is classed according to its principal use.

b. Gas mask and protective clothing.—The service gas mask will give full protection against war gases in concentrations likely to be encountered in the field. It will not protect against carbon monoxide, illuminating gas, ammonia, or cyanide gas. It is therefore not suitable for use in case of industrial accidents or fires. For special operations in extremely heavy concentrations, protective clothing may be necessary. For operations where vesicant gases are present, protective clothing should be worn.

c. References.—There is included in this section only a general treatment of the character and uses of chemical agents, the protection required, first-aid treatment, and decontamination measures. Further information will be found in TM 3-215, TM 9-850, FM 21-10, and FM 21-40.

36. Classification.—Chemical agents are classified according to—

a. Tactical use.—(1) *Casualty agents.*—Used directly against enemy personnel to produce casualties.

(2) *Harassing agents (irritants).*—Used to reduce military efficiency by forcing enemy personnel to mask.

(3) *Screening agents.*—Used to produce an obscuring smoke or fog.

(4) *Incendiary agents.*—Used to cause the ignition of combustible materials.

(5) *Simulated agents.*—Used for testing equipment or training personnel. They are harmless substances whose physical properties are similar to those of the agent represented.

b. Physiological effect.—(1) (*a*) *Lung irritants.*—Incapacitate by damaging lung or bronchial tissue.

(*b*) *Vesicants.*—Cause inflammation, burns, and destruction of tissue both internally and externally.

(*c*) *Lacrimators (tear producers).*—Cause a copious flow of tears and intense, though temporary, irritation of the eyes.

(*d*) *Sternutators (irritant smokes).*—Cause violent headache, nausea, and sneezing, and temporary physical debility.

(2) Any of the above physiological effects may be incidentally produced by an agent having some other primary classification such as incendiary or screening smoke.

c. Purpose.—(1) *Gas.*—An agent which produces either a toxic or irritating physiological effect. Such an agent may be in solid, liquid, or gaseous state before dispersion. Gases are further classified as persistent—those remaining effective at the point of release for more than 10 minutes; and nonpersistent—those which become ineffective within 10 minutes.

(2) *Smoke.*—An agent which produces an obscuring screen.

(3) *Incendiary.*—An agent which produces heat sufficient to ignite combustible materials.

37. Painting and marking.—*a. Painting.*—In general, ammunition is painted to prevent rust and to provide, by means of the color, a ready means of identification as to type. Chemical ammunition is identified by the base color, gray.

b. Marking.—The particular agent used as chemical filler is indicated in the marking on the ammunition by one or two bands and the type of filler and its symbol, all in a distinctive color in accordance with the table in paragraph 38.

38. Description.—*a. General.*—The type, common name, and symbol of the principal chemical agents are included in the table below.

b. Vesicant gases.—The principal persistent casualty agents are mustard gas and lewisite.

(1) Mustard gas (HS) is a dark brown liquid which slowly evaporates to a colorless gas having the odor of garlic. Its principal physiological effect is that of a vesicant although the blistering does not ordinarily appear for several hours. If inhaled, the vapors have a lung-irritant effect. For complete protection against HS, both gas mask and protective clothing are necessary. First-aid measures consist in washing with copious amounts of soap and water or wiping off with organic solvents such as solvent, dry-cleaning, and neutralizing with a thin paste of chloride of lime. Clothing contaminated by HS should be removed at once and decontaminated by airing or steaming. The tactical use of HS is to neutralize areas, contaminate matériel, cause casualties, and harass enemy personnel. It is projected by artillery and mortar in shell, from airplanes by bombs and sprays, and left by retreating troops in land mines. HS renders food and water unfit for use.

(2) Lewisite (M1) is a dark brown liquid evaporating to a colorless gas which has the odor of geraniums. In addition to being vesicant and lung-irritant, lewisite is an arsenical poison. Gas mask and protective clothing are necessary for protection against M1. First-aid measures consist of washing with soap and water, or a 5-percent solution of sodium hydroxide followed by alcohol. Tactical use of M1 and methods of projection are the same as those for HS. It renders food and water permanently unfit for use.

c. Nonpersistent gases.—The principal nonpersistent casualty agents are chlorine, phosgene, and chlorpicrin.

Typical chemical agents

Type	Tactical use	Common name	Symbol	Marking
Persistent gas.	Casualty	Mustard gas	HS	XX* GAS and 2 bands (all in green).
		Lewisite	M1	
Nonpersistent gas.	Casualty	Chlorine	Cl	XX* GAS and 1 band (all in green).
		Phosgene	CG	
		Chlorpicrin	PS	
Irritant gas	Harassing	Tear gas	CN	XX* GAS and 1 band (all in red).
		Tear gas solution	CNB	
		Tear gas-chlorpicrin.	CNS	
		Adamsite	CM	
		Sneeze gas	DA	
Smoke	Screening	HC-Smoke	HC	XX* SMOKE and 1 band (all in yellow).
		FS-Smoke	FS	
		FM-Smoke	FM	
		White phosphorus	WP	
Incendiary	Incendiary	Thermit	TH	XX* INCENDIARY and 1 band (all in purple).
		Barium mixture	FS	
		Thermate	......	
Simulated agents.	Training	Asbestine suspension.	AS	Symbol of agent; type band, and color of agent represented.
		Molasses residuum	MR	

*Symbol of the filler such as CN, WP, HS, etc.

(1) Chlorine (Cl) is a greenish-yellow gas with a pungent odor. Its physiological action is that of lung irritant. For protection the service gas mask is sufficient. First aid consists in removing the casualty to pure air, keeping him warm and quiet, giving mild nonalcoholic stimulants such as coffee or tea, and evacuating as an absolute litter case. Tactical use is as a casualty agent. It is used alone, and with others of this group, in gas cloud attack from cylinders and Livens projector shell. It has a vigorous corrosive action on wet or

moist metals. Food and water contaminated with Cl can be made fit for use under the direction of a medical officer.

(2) Phosgene (CG) appears on projection as a whitish cloud changing to colorless gas. It has the odor of silage or new-mown hay. Physiological action, protection required, first aid, tactical use, action on metals, and action on food and water are the same as for Cl.

(3) Chlorpicrin (PS) is an oily liquid changing slowly in the open to a colorless gas with the odor of flypaper. Physiological action is irritation of eyes, nose, and throat, and, as concentration increases, PS causes nausea and lung irritation. Gas mask is required for protection. First aid is the same as for Cl, for exposure to the vapor. In addition, any splashes of liquid agent on the skin should be washed off, preferably with an alcoholic solution of sodium sulfite. Tactically, it is used in heavy concentrations as a casualty agent and in lighter concentrations as a harassing agent. PS is used with tear gas in artillery and mortar shell, airplane bombs and sprays, with phosgene and chlorine in Livens projector shell, and from cylinders. It has slight action on metals. Contaminated food and water may be rendered fit for use under the direction of a medical officer.

d. Irritant gases.—The harassing agents (irritants) are the lacrimators and the irritant smokes.

(1) Chloracetophenone (CN), commonly known as tear gas, is typical of the lacrimators. It is a solid with a faint fragrant odor which resembles that of apple or locust blossoms. Its physiological action is extreme irritation of the eyes. A gas mask is sufficient for protection. First-aid treatment other than removal to pure air is rarely necessary but in aggravated cases washing out the eyes with boric acid solution will help. CN is used alone in grenades and mortar shell. It is used in solution alone (CNB) and with chlorpicrin (CNS) in artillery and mortar shell, and from airplanes in bombs and sprays. CN has slight action on metals. It imparts only a disagreeable taste to food and water.

(2) The irritant smokes are typified by adamsite (DM). DM is a solid which is dispersed by burning type munitions and appears as a yellow smoke with an odor somewhat resembling coal smoke. Its physiological action is to cause lacrimation, violent sneezing, intense headache, nausea, and temporary physical debility. For protection, the service gas mask, which is equipped with an efficient smoke filter, is required. Treatment other than removal to pure air is seldom necessary although breathing light concentrations of chlorine, as from a bleaching powder bottle, will give relief. Tactical use is as a harassing agent and it can only be used from burning type munitions

such as candles and grenades. DM has slight action on metal but renders food and water permanently unfit for use.

e. Screening smokes.—These are produced by the dispersion of particles in the atmosphere by the burning of solids and by spraying liquids. They are used to screen movements and activity, to blanket the enemy and thus obtain fire superiority, to inactivate observers, to spot artillery fire and bombing, and to disguise cloud gas.

(1) Sulfur trioxide-chlorsulfonic acid mixture (FS) is a liquid which when dispersed into a humid atmosphere produces a dense white smoke. It is projected in shell, by airplane spray, and from portable cylinders. FS liquid is very corrosive and rubber gloves should be worn in handling it. No mask is necessary for the smoke. First aid for FS liquid burns consists of washing with large amounts of water, then with bicarbonate of soda solution, and then treating as for ordinary burns. The smoke is harmless to personnel except in very heavy concentrations. Liquid FS renders food and water unfit for use; the smoke merely imparts an unpleasant taste. On account of its corrosive nature, certain restrictions are in force on the use of FS. (See AR 750-10.)

(2) Titanium tetrachloride (FM) is similar to FS in appearance, properties, and use.

(3) Hexachlorethane-zinc mixture (HC) can be used only from burning type ammunition such as grenades and candles. No protection of personnel or matériel is required. Food and water are not spoiled but acquire a disagreeable odor.

(4) White phosphorus (WP) is a yellow waxy substance which takes fire spontaneously and produces a dense white smoke. Its principal use is to produce smoke although it is an incendiary and casualty agent as well. WP is used only in explosive type projectiles, artillery and mortar shell, and airplane bombs. When the projectile explodes it scatters small pieces of phosphorus which ignite spontaneously. These particles continue to burn even when embedded in the flesh. Phosphorus burns should be kept under water or well packed with moist earth until the particles are removed. Phosphorus smoke is uncomfortable to breathe but harmless; however, the particles will poison food and water.

f. Incendiaries.—Various types of incendiary agents are used. An aluminum-barium nitrate mixture (F8), thermite, or thermate are used in magnesium or steel containers. Thermate, a mixture of thermite with other substances which accelerate the burning, is used in incendiary bombs and grenades. Combustible oils have been used, sometimes with particles of metallic sodium, which re-ignite the oil when water is used to quench the fire. Phosphorus is used, especially against light and inflammable construction. Gasoline and mixtures of gasoline with rubber, alcohol and other substances is used in bombs and grenades. Gasoline-filled bombs have a black powder burster and igniter. The gasoline-filled grenades are glass bottles provided with a pull-wire fuze lighter or other type of igniting fuze.

39. Decontamination.—*a.* Ammunition should be kept in sealed containers. If exposed to mustard gas, however, it must be thoroughly decontaminated before it can be fired. Contaminated ammunition will be cleaned with agent, decontaminating, noncorrosive, or if this is not available, strong soap and cool water. Corroded ammunition will either be cleaned thoroughly or discarded. Agent, decontaminating (chloride of lime), which is used in decontaminating other matériel, will never be used on or near ammunition supplies, particularly in its dry powdered form, as flaming occurs through the use of chloride of lime on mustard. Matériel other than ammunition will be decontaminated according to instructions in TM 9-850, FM 21-40, or TC 38, 1941.

b. The vesicant properties of lewisite can be destroyed through use of the same procedure used for mustard. The products resulting from such decontamination, when washed on the ground, are extremely poisonous because of their arsenic content and will permanently poison drinking water in the vicinity of the contaminated area.

c. Smokes and nonpersistent gases are corrosive to metal, especially in the presence of moisture. The agent must be removed or neutralized to prevent damage to the equipment. Metallic matériel exposed to any of these agents should be cleaned of old oil with a solvent such as gasoline, washed with a solution of sodium carbonate or other alkali, and reoiled. Fabrics and leather exposed to FS must be immediately washed as prescribed in paragraph 13, AR 750-10.

CHAPTER 2

BASIC TYPES OF AMMUNITION

SECTION I

SMALL-ARMS AMMUNITION

40. General.—*a.* The information in this section is limited to a general description of the several types of small-arms ammunition used for military purposes. Many types are manufactured to the same profile, consequently cartridges of the same caliber although of different model may be very similar in appearance. Each type has a characteristic marking which is described in this section. Different models of the same type may be identified by the marking on the packing boxes and cartons. A detailed description of each type and model, including characteristics, means of identification.

care and handling, packing, and marking will be found in TM 9-1900.

b. Small-arms ammunition comprises the ammunition used in small-arm weapons—rifles, pistols, revolvers, and machine guns in calibers .22, .30, .45, and .50, and shotguns of 12-gage.

41. Cartridges.—*a. General.*—A round of small-arms ammunition is known as a cartridge. In general, it consists of a bullet, a propelling charge, a primer, and a cartridge case, made into a unit assembly. Figure 5 shows a typical cartridge in section with the various parts named.

b. Bullet.—Bullets for service use have a metal core which is covered with a gilding metal jacket. A cannelure is generally rolled or cut into the jacket to provide a recess into which the cartridge case is crimped.

c. Propelling charge.—There are two types of small-arms propellants generally used, the single-base nitrocellulose type and the double-base type. The double-base type is a mixture of nitrocellulose and nitroglycerin which burns more rapidly than the single-base type. The weight of the charge and granulation of the powder is in accordance with specification requirements for velocity and pressure. The charge is assembled loosely in the cartridge case.

d. Primer.—The primer consists of a brass or gilding metal cup which contains a primer composition pellet of sensitive explosive, a paper disk, and a brass anvil.

e. Cartridge case.—The cartridge case is of drawn brass. It serves as a means whereby the other components, the primer, the propelling charge and the bullet, are assembled into a unit, the cartridge. Another of its functions is to seal the chamber against the escape of gases to the rear when the cartridge is fired. This action is known as obturation. To make the cartridge waterproof, the primer is sealed in the primer seat and the bullet is sealed in the neck of the cartridge case by a thin film of lacquer or varnish at the time of manufacture.

42. Types.—Small-arms cartridges are classified according to type as follows:

a. Ball.
b. Armor-piercing.
c. Tracer.
d. Incendiary.
e. Blank.
f. Gallery practice.
  (1) Caliber .22 (present standard).
  (2) Caliber .30 (now used for guard purposes only).
g. Guard.

h. Subcaliber.
i. High-pressure test.
j. National Match.
k. Dummy.
l. Shotgun shells.

43. Ball.—This type of cartridge, intended for use against personnel and light matériel targets, is the most widely used of the service types. The term "ball," although no longer accurately describing the shape of the modern bullet, has been continued in use to designate that type of bullet and ammunition used for the same purposes as ammunition of very early design, the bullet of which was actually a ball. Typical ball cartridges of different calibers are shown in figure 4.

44. Armor-piercing.—This type of cartridge, intended for use against armored aircraft, armored vehicles, concrete shelters, and similar bullet-resisting targets, is characterized by the bullet, which has an armor-piercing core. It is distinguished from other types of ammunition by the nose of the bullet, which is painted black. A typical armor-piercing cartridge is shown in figure 6.

45. Tracer and incendiary.—*a. Tracer.*—This type of cartridge is intended for use with other types to show the gunner, by its trace, the path of the bullets. It is also used for incendiary purposes. The nose of the bullet is painted red to correspond to the color of the trace to distinguish it from other types. Figures 8 and 9 show typical rounds of tracer ammunition.

b. Incendiary.—This ammunition in calibers .30 and .50 resembles the ball or armor-piercing ammunition in outward appearance. It may be identified by the light blue paint on the tip of the bullet.

46. Blank.—This type of cartridge is distinguished by the absence of bullets. It is used for simulated fire, training cavalry mounts, signaling, and firing salutes; also in machine guns equipped with blank firing attachments, in order to operate these weapons for instructional purposes. For precautions in firing blank ammunition, see TM 9-1900. Although other blank cartridges may be found in service, only those authorized in TM 9-1900 will be fired. Typical blank cartridges are shown in figures 7 and 10.

47. Gallery practice.—*a.* The present standard ammunition for gallery practice is the cartridge, ball, caliber .22, long rifle (fig. 4)—a rim fire cartridge of commercial manufacture.

b. The former standard gallery-practice ammunition, cartridge, gallery practice, caliber .30, M1919, is now reserved for guard purposes. It is shown in figure 4.

48. Guard.—This type of cartridge, the bullet of which has a much lower velocity than that of service ammunition, is provided for guard purposes. The cartridge, guard, caliber .30, M1906, as currently issued is identified by six short corrugations just below the shoulder of the cartridge case. It is no longer standard. Therefore when stocks are exhausted, this model will be superseded by the cartridge, guard, caliber .30, M1.

49. Subcaliber.—This type of cartridge is designed for use in conjunction with subcaliber tubes in cannon for training personnel in conduct of fire. It is identified by the extracting rim on the head of the case instead of the usual groove.

50. High-pressure test.—This type of cartridge is manufactured for use in the proof firing of small-arms weapons. Since the propelling charge of this ammunition is designed to develop excessive pressure, these cartridges should never be used for any other purpose, and when used for the purpose intended, all personnel should be protected by adequate cover. This ammunition is distinguished from other types by the tin coating of the cartridge case. In some models the word "TEST" is stamped on the heads of the cartridge cases.

51. National Match.—These are manufactured each year for the National Matches of that year. The following year they may be used in preliminary firing for such matches. The second year, and thereafter, they are considered standard service ammunition. National Match ammunition is packed in blue boxes in contrast to the usual brown and the head of each cartridge is stamped "N. M." and with the year of manufacture.

52. Dummy.—Dummy cartridges are provided for training and practice in loading and in simulated fire. Such ammunition is inert. For identification, the cartridge case is tinned and the primer omitted. Earlier designs containing an inert primer are identified by holes in the body of the cartridge case.

53. Shotgun shells.—Shotgun shells (shot shells) of appropriate loads in 12-gage are provided for the following purposes:

a. For guard and combat use.

b. For trapshooting.

c. For hunting.

54. Grades.—Current grades of existing lots of small-arms ammunition are established by the Chief of Ordnance and are published in OFSB 3-5. No lots other than those of current grade appropriate for the weapon will be fired. Grade 3 indicates unserviceable ammunition which will not be fired.

55. Care and precautions in handling.—*a.* Small-arms ammunition is comparatively safe to handle. However, care must be taken to prevent ammunition boxes from becoming broken or damaged. All broken boxes will be immediately repaired and careful attention

given to the transfer of all markings to the new parts of the box. The metal liners should be air tested and sealed if equipment for the work is available.

b. Ammunition boxes should not be opened until the ammunition is required for use. Ammunition removed from airtight containers, particularly in damp climates, is apt to corrode, thereby causing it to become unserviceable.

c. When cartridges are taken from their original packings for loading into clips or machine-gun belts, the clips or belts should be so tagged or marked as to preserve the ammunition lot number, thereby preventing the ammunition from falling into grade 3 through loss of lot number.

d. Ammunition should be carefully protected from mud, sand, dirt, and water. If it gets wet or dirty, it should be wiped off at once. Should light corrosion or verdigris form on cartridges, it should be wiped off. However, cartridges should not be polished to make them look brighter or better.

e. The use of oil or grease on cartridges is dangerous and is prohibited.

f. Cartridges that are dented, those that have loose bullets, and those otherwise defective should not be fired.

g. For further information, see sections I and VI and TM 9-1990.

56. Precautions in firing.—*a.* Because a misfire cannot immediately be distinguished from a hangfire, it is unsafe to open the bolt of a rifle immediately when a misfire occurs. When the rifle M1, caliber .30, fails to fire, it should be recocked by operating the trigger guard and refired before opening the bolt.

b. For other rifles, in the event of misfire, the rifle should be recocked by drawing back the cocking piece and refired before opening the bolt.

c. Before firing, the firer should be sure that the bore of the weapon is free of any foreign matter such as cleaning patches, mud, sand, snow, and the like. To fire a weapon with any obstruction in the bore will damage the weapon and may result in injury to the firer.

d. Ammunition should not be exposed to the direct rays of the sun for any considerable length of time. This is likely to affect its firing qualities seriously.

e. No small-arms ammunition will be fired until it has been identified positively by ammunition lot number and grade as published in the latest revision of OFSB 3-5.

f. Any serious malfunction of ammunition must be reported promptly to the ordnance officer under whose supervision the material is maintained and issued. The ordnance officer will report such malfunction to the Chief of Ordnance as provided in AR 45-30. It is important, therefore, that all evidence be preserved. This includes the cartridge case, the other cartridges from the same box, the weapon concerned, all recoverable pieces—in short, everything that might throw light on the cause of the malfunction.

57. Packing and marking.—Detailed packing and marking regulations are given in TM 9-1990. The following table shows the method of packing and the identifying color band on the packing boxes for the various types of small-arms ammunition. Typical packing boxes are shown in figure 11.

Type	Primary band [1]	Superimposed band [1]	Packing
Ball, cal. .30	Red	None	Cartons, 5- and 8-round clips in cartons or bandoleers, web or link belts.
Ball, cal. .45	Red	None	Cartons.
Ball, cal. .50	Red	None	Cartons, link belts.
Blank, cal. .30	Blue	None	Cartons.
Blank, cal. .45	Blue	None	Cartons.
Dummy, cal. .30	Green	None	Cartons, 5-round clips in cartons.
Dummy, cal. .45	Green	None	Cartons.
Dummy, cal. .50	Green	None	Cartons.
Guard, cal. .30	Orange	None	Cartons, 5-round clips in cartons.
Armor-piercing, cal. .30.	Yellow	Blue	Cartons.
Armor-piercing, cal. .50.	Yellow	Blue	Cartons.
Tracer, cal. .30	Yellow	Green	Cartons.
Tracer, cal. .45	Yellow	Green	Cartons.
Tracer, cal. .50	Yellow	Green	Cartons.
Gallery practice, cal. .30.	Brown	None	Cartons.
Cartridge, carbine, cal. .30, M1.	Red	None	Cartons.
Subcaliber, cal. .30	None	None	Cartons.
High-pressure test, cal. .30.	Yellow	None	Cartons.
High-pressure test, cal. .45.	Yellow	None	Cartons.
High-pressure test, cal. .50.	Yellow	None	Cartons.
Blank, cal. .50	Blue	None	Cartons.
Ball and tracer, cal. .30.	Yellow, red, green (3-stripe band).		Link belts

Type	Primary band [1]	Superimposed band [1]	Packing
Ball and tracer, cal. .50.	Yellow, red, green (3-stripe band).		Link belts.
Incendiary, cal. .30	Yellow	Red	Cartons.
Incendiary, cal. .50	Yellow	Red	Cartons.
Cartridge, rifle, grenade, cal. .30, M3.	Two blue bands separated by band width.	None	

[1] Bands on the face of boxes for caliber .30 and caliber .45 ammunition are vertical; bands on the ends are horizontal. Bands on boxes for caliber .50 ammunition are diagonal on all sides. Markings on caliber .50 boxes include color oblongs.

A — CARTRIDGE, BALL, CAL. .22, LONG RIFLE
B — CARTRIDGE, BALL, CAL. .45, M1911
C — CARTRIDGE, CARBINE, CAL. .30, M1
D — CARTRIDGE, BALL, CAL. .50, M2
E — CARTRIDGE, BALL, CAL. .30, M2
F — CARTRIDGE, GUARD, CAL. .30, M1

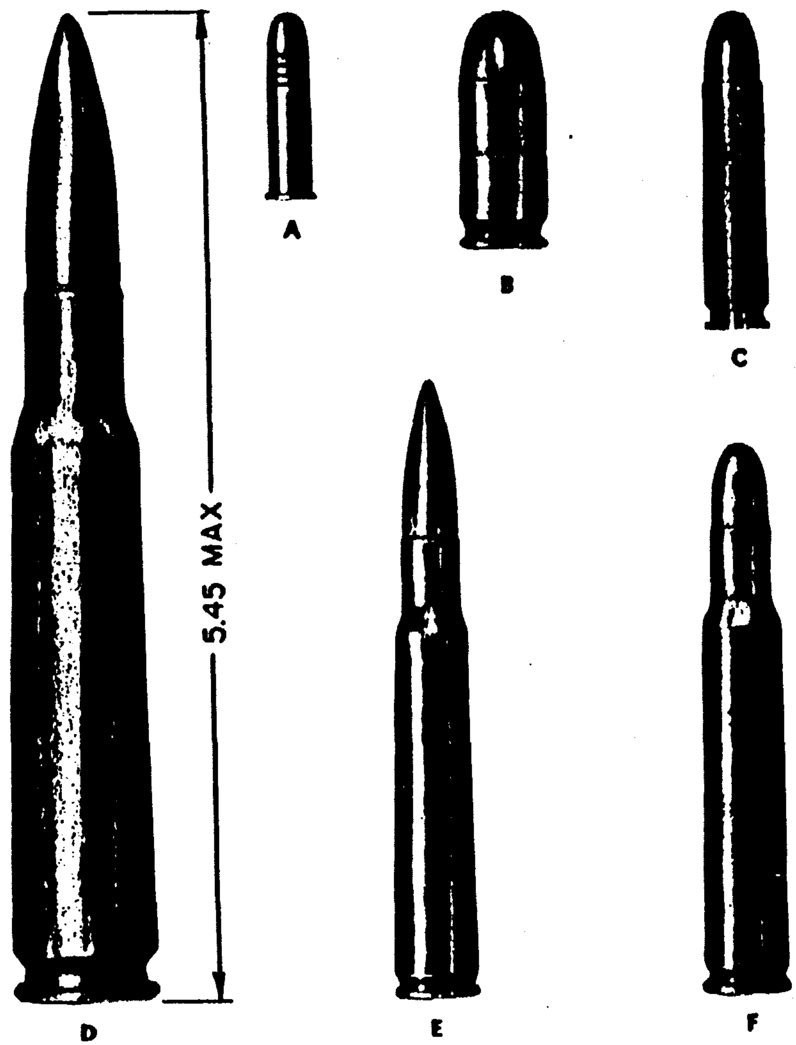


Figure 4. Typical ball cartridges.

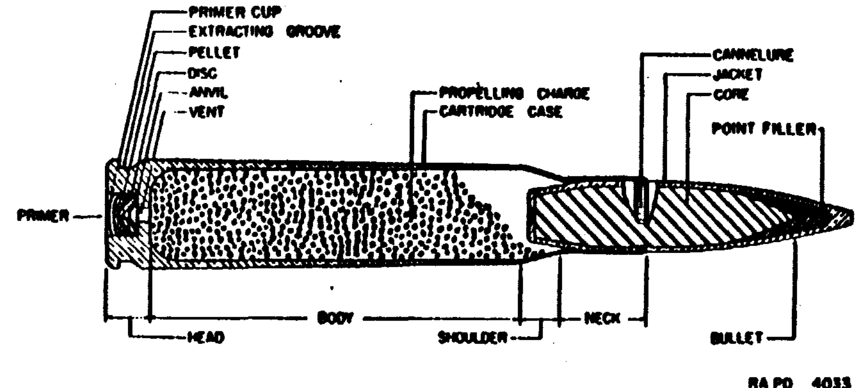


Figure 5.—Section of ball cartridge, caliber .50.

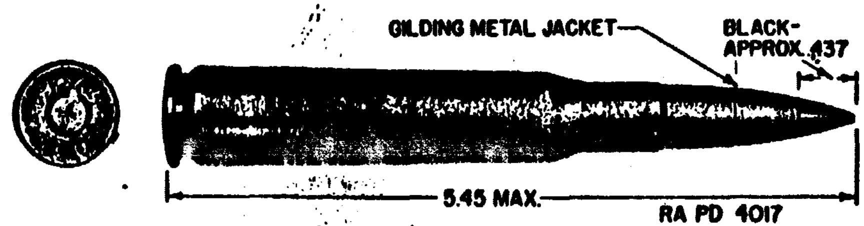


Figure 6.—Cartridge, armor-piercing, caliber .50.

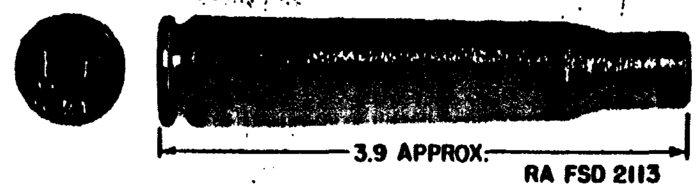


Figure 7.—Cartridge, blank, caliber .50.

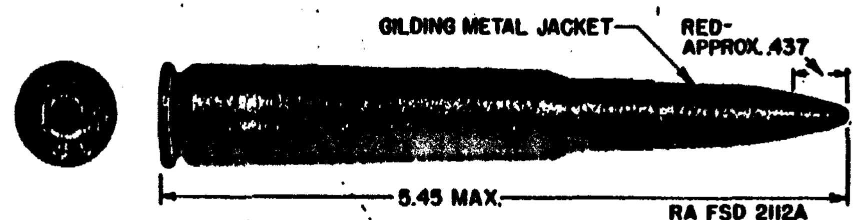


Figure 8.—Cartridge, tracer, caliber .50.

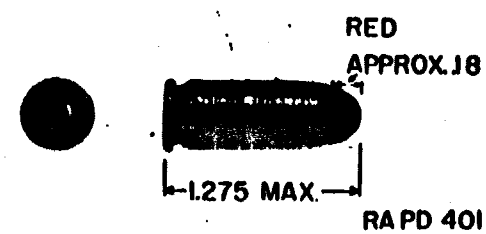


Figure 9.—Cartridge, tracer, caliber .45.

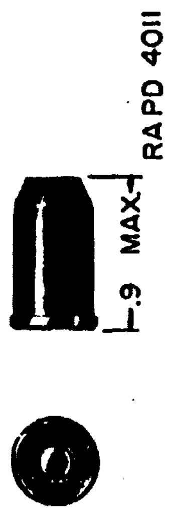


Figure 10.—Cartridge, blank, caliber .45.

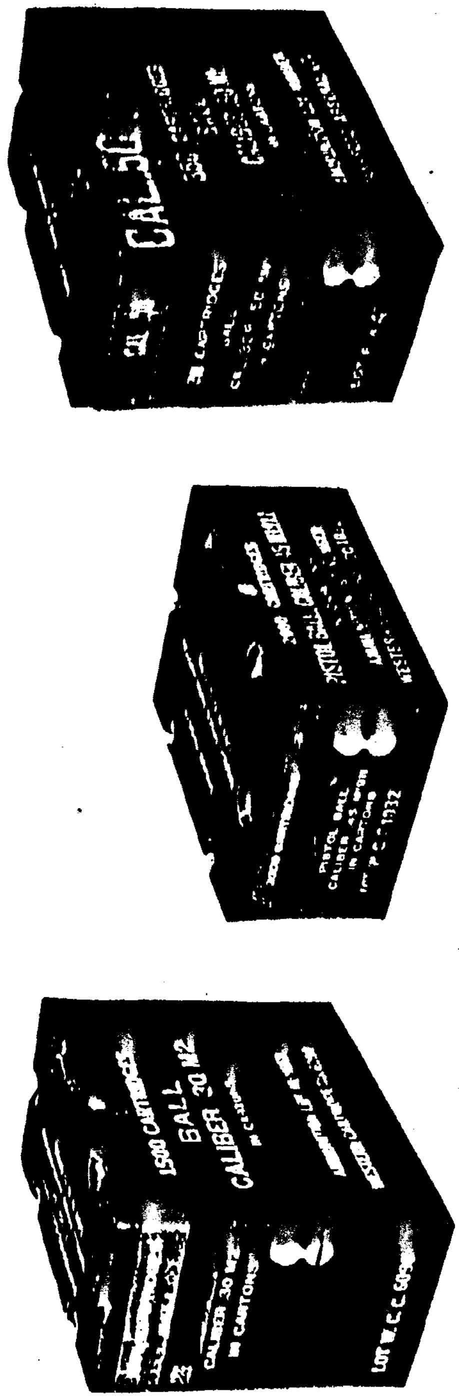


Figure 11.—Small-arms ammunition packing boxes.

Section II

GRENADES

58. Description and classification.—*a. General.*—Grenades are explosive or chemical missiles, intended for use at relatively short range. Although usually designed to be thrown by hand, they may be made for use with a rifle or other type of projector. Grenades are very effective for augmenting primary weapons such as the rifle in trench warfare, for dispersing mobs, quelling riots, etc. The grenades thrown by hand are fitted with a delay action fuze, the delay for explosive grenades being slightly more than the average time of flight, 5 seconds; for chemical grenades, slightly less than the average time of flight, 2 seconds.

b. Types.—There are two basic types of grenades: those designed to be thrown by hand, and those designed to be projected by rifles or other launchers, generally termed rifle grenades. Hand grenades are classified into four general types: fragmentation grenades, offensive grenades, chemical grenades, and practice or training grenades. Rifle grenades are classified as antitank and practice.

59. Fragmentation and offensive grenades.—*a. Fragmentation grenades.*—Fragmentation grenades contain an explosive charge provided to break the body of the grenade and project fragments at high velocity. To assist in the formation of uniform fragments the body is serrated, horizontally and vertically. It is made of cast iron in the shape of a large lemon, approximately 2¼ inches in diameter by 4½ inches long (fig. 12). The standard bursting charge is E. C. firing powder, which is exploded by an igniting fuze. Fuzes for all types of fragmentation and practice grenades are designed to function after 5 seconds' delay.

b. Offensive grenades.—Offensive grenades are made of paper or fiber container and a high explosive filler. They are used for demolition of matériel and emplacements. They are equipped with a detonating fuze with 5 seconds' delay. The grenade, hand, offensive, Mk. IIIA1, representative of this type, contains approximately ½ pound of pressed TNT.

60. Chemical grenades.—Chemical grenades contain a "burning mixture" which, when ignited by its fuze, produces an irritant gas or an obscuring smoke. These are known as gas grenades or smoke grenades. The body of the chemical grenade is a short cylinder approximately 2½ inches in diameter by 5½ inches long (fig. 12). Fuzes for chemical grenades are designed to function with 2 seconds' delay.

61. Rifle grenades.—*a.* The present standard rifle grenades are specialized grenades for use against armored targets. They are designated grenade, AT, M9 and M9A1. They have a steel body containing the high explosive and a fuze assembly and a tail assembly, consisting of a hollow tube and a wheel-shaped fin. The fuze functions upon impact. A safety pin located on the body of the grenade must be removed to arm the fuze. The fuze in the grenade, AT, M9, will normally detonate only upon impact with a hard resistant body. The fuze of the M9A1 grenade is more sensitive and will function upon impact with soft earth. These grenades are to be fired only from the rifle, caliber .30, M1903 or M1917. They are projected by use of a launcher which fits on the muzzle of the rifle. A special cartridge, designated cartridge, rifle grenade, M3, must be used for projecting these grenades. The grenades are packed in kits containing 10 grenades, a launcher for either the M1917 or M1903 rifle, sights, and recoil pad. A cartridge is packed with each grenade in a cellophane wrapper in the tube of the grenade.

b. The grenade, AT, M10, is similar in shape and function to the grenade for use with the caliber .30 rifle. It is larger and is projected by use of a special projector.

62. Training grenades.—*a.* A grenade of the same size, shape, and weight as the fuzed fragmentation grenade, but inert, is provided for training in throwing. The grenade formerly used for such purposes was made of cast iron and was known as grenade, hand, dummy, Mk. I. This design has recently been modified by adding a pull ring and safety pin (cotter pin), thereby more closely simulating the fragmentation grenade. This modified grenade is known as grenade, hand, training, Mk. IA1, and is shown in figure 12.

b. A practice grenade, known as grenade, hand, practice, Mk. II, with hand grenade igniting fuze M10A1, was formerly standard for practice purposes. It contains a small charge of black powder and a live fuze, and is painted blue to distinguish it from the training grenade.

c. The practice grenades designated grenade, AT, practice, M11 and M13, are of the same size and appearance as the explosive types M9A1 and M10 respectively. They are provided for training and practice in aiming and firing. These grenades are inert and may be fired a

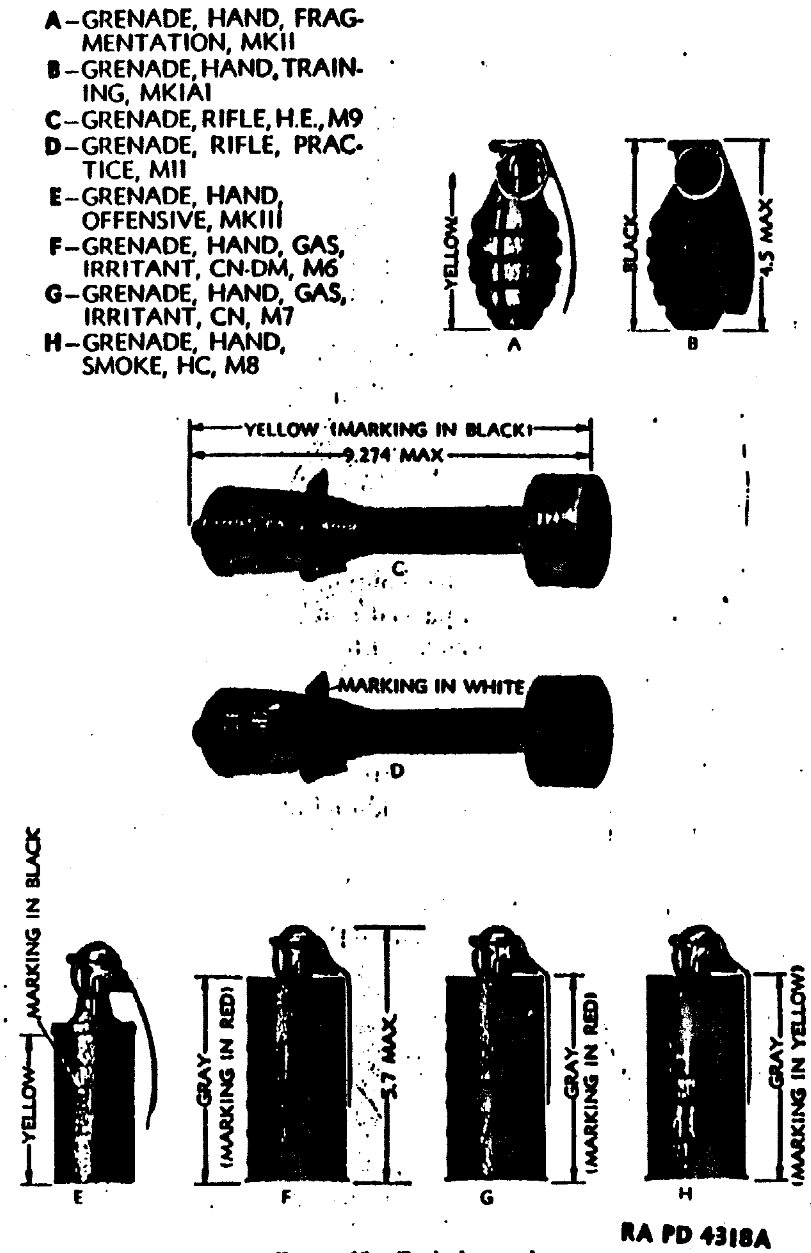


FIGURE 12.—Typical grenades.

number of times if they are not damaged. Replacement fin assemblies and extra cartridges are provided separately. The cartridge used for launching is the same as that used for the corresponding explosive type.

63. Care and precautions in handling.—*a. Care.*—Information concerning the care to be exercised in handling grenades will be found in chapters 1 and 3 of this manual and in FM 23-30.

b. Precautions.—In addition to the general safety precautions in handling ammunition given in sections I and VI, chapter 3, the following will be observed:

(1) Since fragments may be projected over 200 yards, fragmentation grenades will not be used in training without adequate cover.

(2) The safety (cotter) pin will be removed just before throwing and at no other time.

(3) Chemical grenades may occasionally flash, hence, when used in maneuvers, they will be so thrown as to function not less than 20 feet from personnel.

(4) Duds will be disposed of in accordance with the provisions in chapter 4.

64. Packing and marking.—*a. Packing.*—The present practice is to pack fragmentation and chemical grenades, as fuzed complete rounds, each in an individual fiber container, 25 in a wooden packing box. Some packings on hand, packed under older standards, contain 10 grenades to the metal-lined box. Others contain unfuzed grenades, 25 per box.

b. Marking.—Fragmentation grenades and those containing high explosives are painted yellow. Chemical-filled grenades are painted gray with band and symbol of filler stenciled on the side. (See table in par. 38.) Practice grenades are painted blue. Training grenades, inert, are painted black.

Section III

ANTITANK MINES

65. General.—The antitank mine is an explosive device designed to be laid on the ground or planted flush with the surface for defense against armored cars and tanks.

66. Classification.—At the present time there is one model each of service and practice antitank mines, the mine, antitank, HE, M1, and the mine, antitank, practice, M1, figures 13 and 14, respectively.

67. Mine, antitank, HE, M1.—*a. General.*—This mine with principal data and markings is shown as a complete round assembly in

figure 13. The complete round consists of two components, the loaded mine body and the fuze. The disassembled components are shown in figure 15. A separable part of the body which fits over the fuze to increase the effective size of its head is known as the spider.

b. Description.—The steel body is cylindrical, approximately 2¾ inches high and 7½ inches in diameter. The flanged rim around the top is notched in two places for assembling the spider. In the center of the top is the fuze cavity, approximately 2 inches in diameter and 2$^{9}/_{16}$ inches deep. A carrying ring is attached to the side of the mine. The complete round, mine and fuze, weighs approximately 10.4 pounds; the high explosive filler, 6 pounds. The spider consists of a ring and two cross members with a hook on each end, riveted together as shown in figure 15. These hooks engage the flange on the mine body and the center of the spider rests on the striker head of the fuze.

c. Fuze, mine, antitank, HE, M1.—This fuze (fig. 15), which contains the booster as an integral part, is used only in the high explosive mine. It consists essentially of a striker assembly and a body which contains the primer, detonator, and booster. The striker assembly, on the outer end of which is a 2-inch diameter head, protrudes approximately ⅜ inch beyond the body of the fuze. The firing mechanism, contained within the striker assembly, is restrained from firing when in the armed condition (safety fork withdrawn) by the collar just below the head and two shear pins. A force of approximately 500 pounds on the striker head is required to actuate the firing mechanism. When assembled to the mine with the spider in place, a force of approximately 250 pounds applied to the rim of the spider will actuate the firing mechanism. For safety in shipping and handling, a safety fork, attached to the striker head by a cord, is fitted over the collar between the striker head and the top of the fuze body. The safety fork will not be removed except when it is intended to arm the fuze.

d. Assembly (fuzing and arming).—The following steps are required to assemble the complete round:

(1) Remove the spider from the bottom of the body.

(2) Insert fuze in fuze cavity. Push the fuze down until it latches. When thus assembled the upper surface of the fuze body is flush with the upper surface of the mine.

NOTE.—Before inserting fuze, be sure that the fuze cavity is clear—no foreign matter present.

(3) Assemble spider. To assemble the spider, aline, but do not engage, two of the hooks with the two notches in the flange of the body. Engage the other two hooks over the flange on the body. Next press the first two hooks through the notches, then rotate the spider

approximately 1/8 turn in either direction to secure the spider to the body.

(4) Plant mine, recording its location.

(5) Withdraw safety fork, thereby arming the fuze. The safety fork should be left beside the mine, attached to its cord—never between the body and spider.

e. Disassembly (unfuzing and disarming).—Mines may be disarmed and taken up by reversing the steps in *d* above.

68. Mine, antitank, practice, M1.—*a. General.*—This mine with principal data and markings is shown as a complete round assembly in figure 14. The complete round consists of two components, an empty mine body (which includes the spider), and a fuze.

b. Description.—These parts are similar in appearance to the corresponding parts of the high explosive mine except that the body has five 1-inch holes equally spaced around the side. There are differences in color and marking which are described in paragraph 70.

(1) Fuze, mine, antitank, practice, M1, is similar in form and operation to the fuze for the high explosive mine described above, except that it contains a smoke-puff charge in place of the booster element.

(2) Fuze, dummy (antitank mine), is completely inert. It is made of metal or plastic to simulate the service fuze and has a removable safety fork.

(3) These fuzes are used with the practice mine body for training and practice.

(4) Differences in painting and marking are described in paragraph 70.

c. Assembly (fuzing and arming).—The practice mine is assembled in the same manner as the mine, antitank, HE, M1, described in paragraph 67.

d. Disassembly unfuzing and disarming.—See paragraph 67*e*.

69. Care and precautions in handling.—In addition to the general provisions of chapters 1 and 3, the following will be observed:

a. Safety fork.—The safety fork will not be removed except when it is intended to arm the fuze. The fork is not removed until after the mine has been planted. Should the mine be taken up, the safety fork will first be replaced.

Caution: Care will be exercised that no undue load is accidentally brought to bear on the spider, especially the rim, after the safety fork has been removed. A load of approximately 250 pounds on the rim of the spider will actuate the firing mechanism.

b. Mines laid singly.—To prevent sympathetic detonation of part or all of a mine field, mines laid singly on the ground should be 3 feet or more apart; if planted flush, 2 feet or more apart.

c. Mines laid in multiple.—Should it be required to lay mines in multiple to give a more powerful blast, the mines may be buried one on top of another, or side by side, planted flush, or laid on the surface. If planted flush, adjacent mines should be in contact; if laid on the surface, they may be as much as 18 inches apart. Such planting will insure that all mines in the group will detonate when any one detonates. To prevent sympathetic detonation of part or all of the groups in a mine field, the distances given in *b* above should be correspondingly increased.

70. Packing and marking.—*a. Packing.*—Antitank mines are packed in a wooden box which contains five mines and five fuzes (fig. 16). Two data cards are inclosed, one loose and one attached to the inside of the cover so that the instructions are visible. The box is made up with a set of plywood separators and two sets of grooves. As shipped, the fuzes are placed in a fuze container which occupies one compartment of the box; the five mines, with spiders nested to the bottoms, are packed, carrying ring up, one in each of the other five compartments. For convenience in carrying fuzed mines in the field, the same box, but with the partitions moved to the second set of grooves, may be used. The box with five high explosive mines and fuzes weighs approximately 67 pounds. The box with five practice mines and fuzes weighs approximately 62 pounds.

b. Marking.—(1) The mine, antitank, HE, M1, is painted yellow with marking in black. The mine, antitank, practice, M1, is painted blue with marking in white. The marking on the head of both types includes—

(*a*) Type and model of mine.
(*b*) Lot number.
(*c*) Manufacturer's initials or symbol.
(*d*) Date loaded.

(2) The striker head of the fuze, mine, antitank, HE, M1, is painted yellow, that of the fuze, antitank, practice, M1, red. Both are marked in black on the side with—

(*a*) Designation of fuze.
(*b*) Loader's lot number.
(*c*) Loader's initials.
(*d*) Date loaded.

(3) The end cleats of boxes containing practice mines are painted blue and in addition there is a 3-inch blue band around the middle. Boxes for high explosive mines are unpainted. Representative markings on the box are shown in figure 16. For further information see chapters 1 and 3.

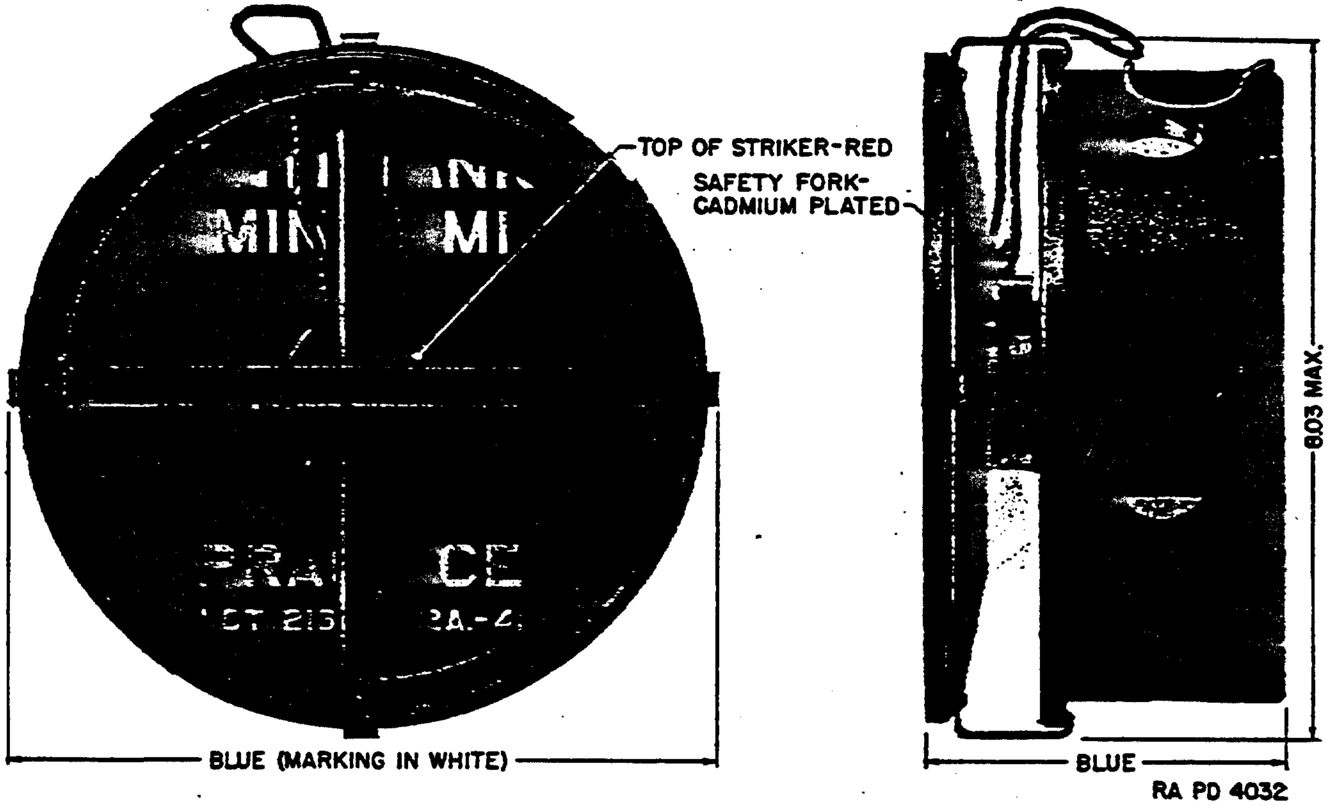


Figure 14.—Mine, antitank, practice, M1.

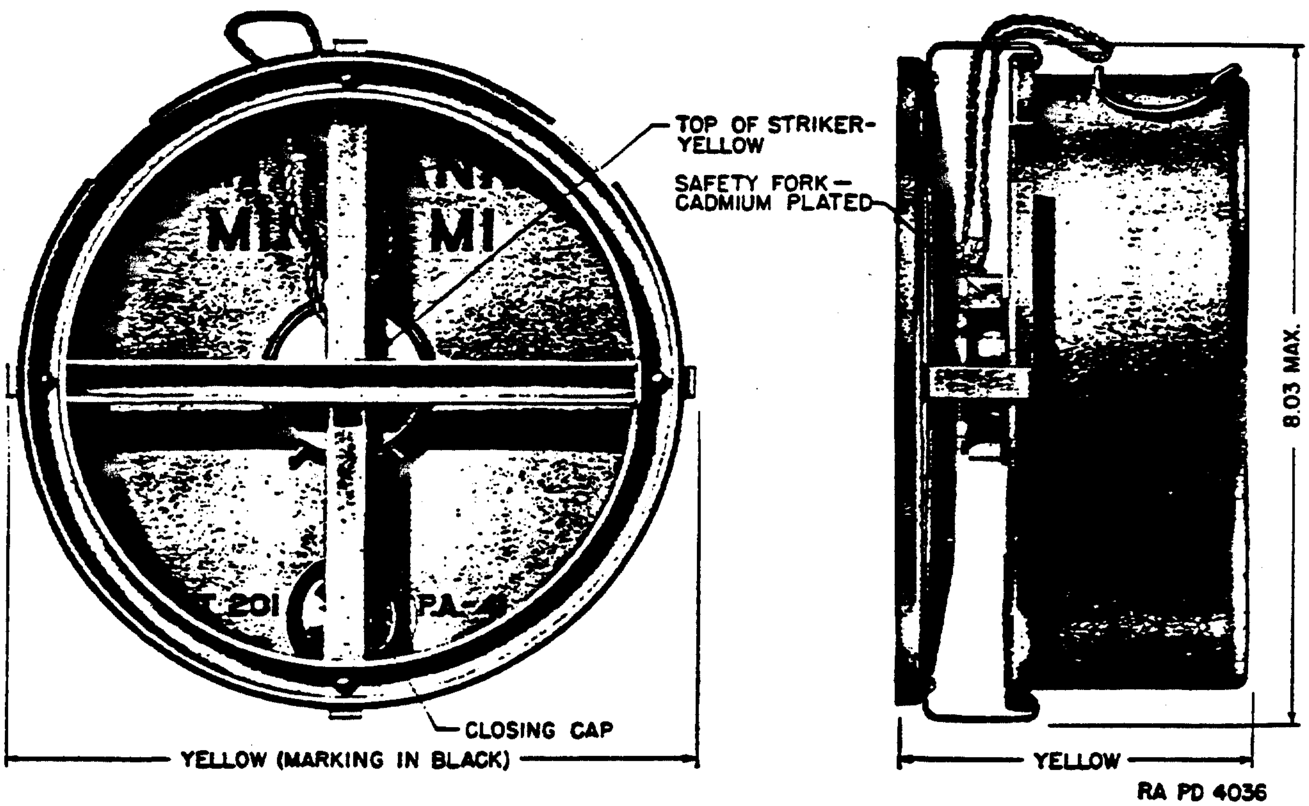


Figure 13.—Mine, antitank, high explosive, M1.

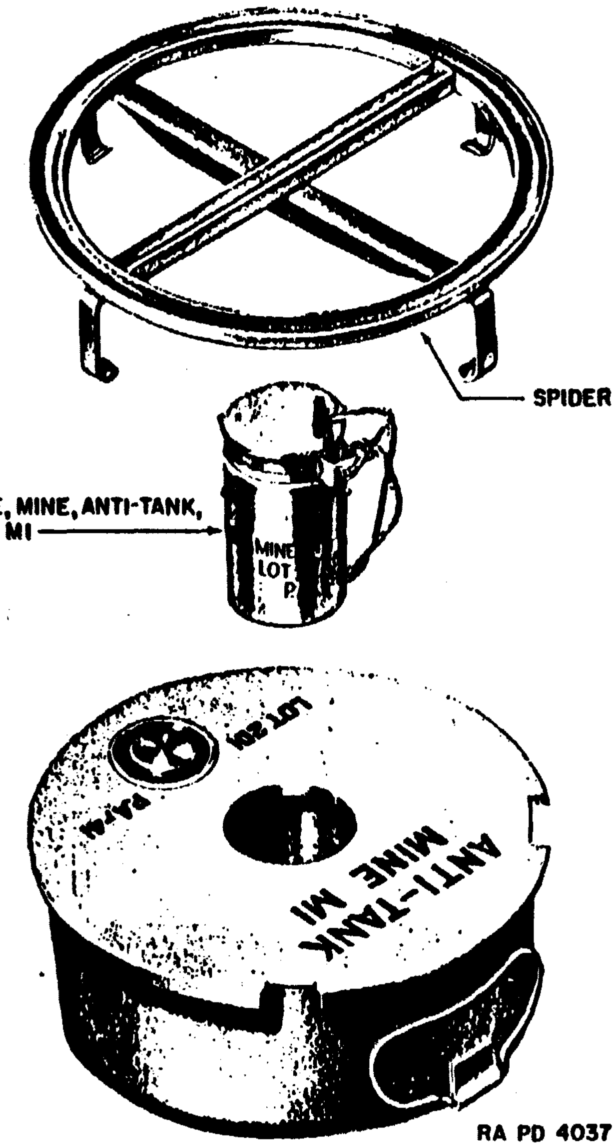


FIGURE 15.—Mine, antitank, components.

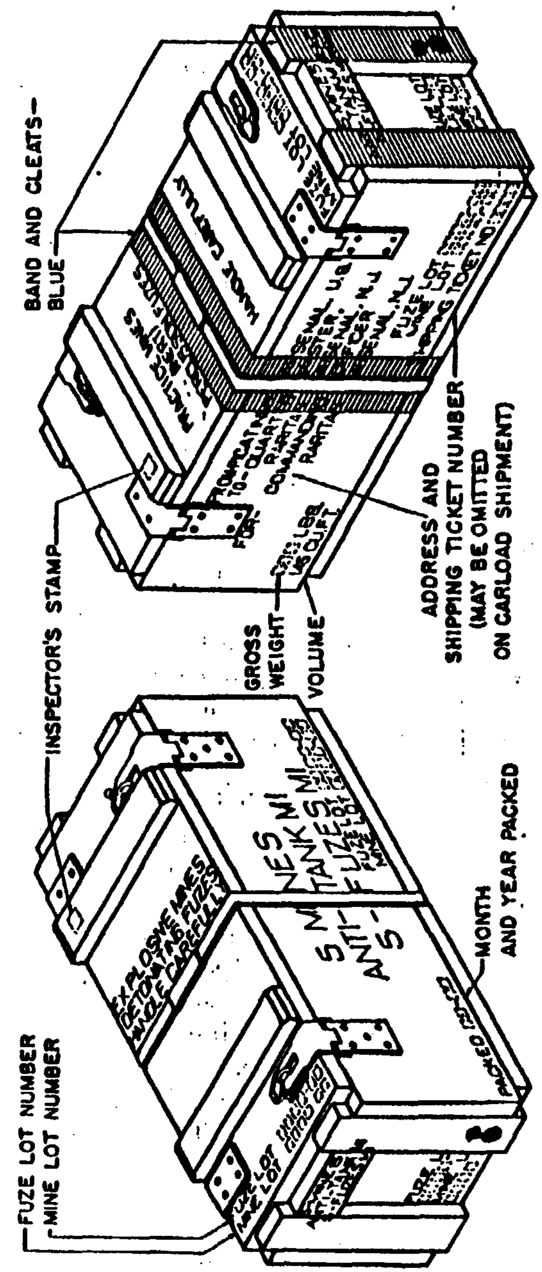


FIGURE 16.—Packings for antitank mines.

Section IV

MORTAR AMMUNITION

71. General.—Mortar ammunition (fig. 17) is designed for firing from smooth-bore cannon at high angles of fire and at ranges less than those of field artillery. Such weapons and ammunition are particularly effective in stabilized trench warfare, hence have been commonly known as trench mortars and trench mortar ammunition. In the ammunition of early design, the projectile, not being stabilized, tumbled in flight. To meet requirements for greater range and accuracy, recently designed projectiles are stabilized by fins. To provide for high angle fire at various ranges (zones of fire), the propelling charge, which is attached to the base of the projectile, is divided into parts, consisting of an ignition cartridge and the required number of propellent increments. In earlier design the ignition cartridge consisted of a primed shotgun shell containing a charge of propelling powder. As currently manufactured, the ignition cartridge and primer are separate elements, the primer being designed to screw into the cartridge container (base end of the projectile) after the ignition cartridge has been inserted. Because it is designed for loading into the mortar as a unit and contains provisions for adjusting the propelling charge, mortar ammunition is classified as semifixed ammunition. The 8-inch mortar and its ammunition are limited standard.

72. Classification.—According to the purpose for which it is intended, mortar ammunition is classified as high explosive, chemical, practice, or training.

a. High explosive shell are used for fragmentation or demolition effect according to the action of the fuze.

b. The chemical fillers currently authorized for use only in 81-mm mortar ammunition are smoke and gas. There is no chemical filler authorized for 60-mm mortar ammunition.

c. Practice shell may have a spotting charge or be inert.

d. Training projectiles are provided for training and practice. They are inert and are designed to be fired more than once. Several propelling charges are supplied with each projectile.

73. Description.—*a. General.*—Two general types of ammunition are authorized for use in the 81-mm mortar and 3-inch trench mortar. That originally designed for the 3-inch trench mortar is limited

standard and is commonly known as 3-inch trench mortar ammunition to distinguish it from the ammunition designed originally for the 81-mm mortar. Under certain restrictions as to use of the full propelling charge (see below), both types of ammunition may be used in either weapon. The 81-mm mortar ammunition is issued as fuzed complete rounds with full (outer zone) propelling charge, whereas the 3-inch trench mortar ammunition is issued as unassembled complete rounds which must be assembled prior to firing. The 60-mm mortar ammunition is issued as fuzed complete rounds, similar to the 81-mm mortar ammunition.

b. 81-mm mortar ammunition.—Because of its stabilizing fins, this ammunition (fig. 17), even though fired from a smooth-bore mortar, is stable in flight and strikes nose first. A point-detonating type of fuze is fitted to the nose of the shell. The propelling charge, consisting of an ignition cartridge and propellent increments, is attached to the base end of the projectile. The increments are removable to provide for zone firing. When fired in the mortar, trench, 3-inch, Mk. IA2, the full (outer zone) propelling charge will be reduced as prescribed in the firing table.

c. 3-inch trench mortar ammunition.—This ammunition, which is limited standard (fig. 17), has no stabilizing fins, and because it is fired in a smooth-bore mortar which imparts no rotation to the projectile, is unstable in flight and may strike the target in any position—nose first, base first, or on its side. Hence it requires a fuze which will function regardless of the position of the projectile at the instant of impact. Such a fuze, known as the "Allways," is provided for assembly to the nose of the shell. The propelling charge, consisting of an ignition cartridge and propellent increments in the form of powder rings, must be attached to the base of the projectile prior to firing. The full (outer zone) propelling charge of this ammunition may be used when fired either in the mortar, 81-mm, M1, or mortar, trench, 3-inch, Mk. IA2.

d. 60-mm mortar ammunition.—Except for size, this ammunition is of the same general design as the 81-mm mortar ammunition. A typical round is shown in figure 17.

74. Care and precautions in handling.—General precautions given in chapters 1 and 3 will be observed. In addition the following will be complied with:

a. Complete rounds, being fuzed, will be handled with due care at all times. The explosive elements in primers and fuzes are particularly sensitive to shock and high temperature.

b. Just before firing and at no other time, the safety (cotter) pin will be withdrawn from the fuze.

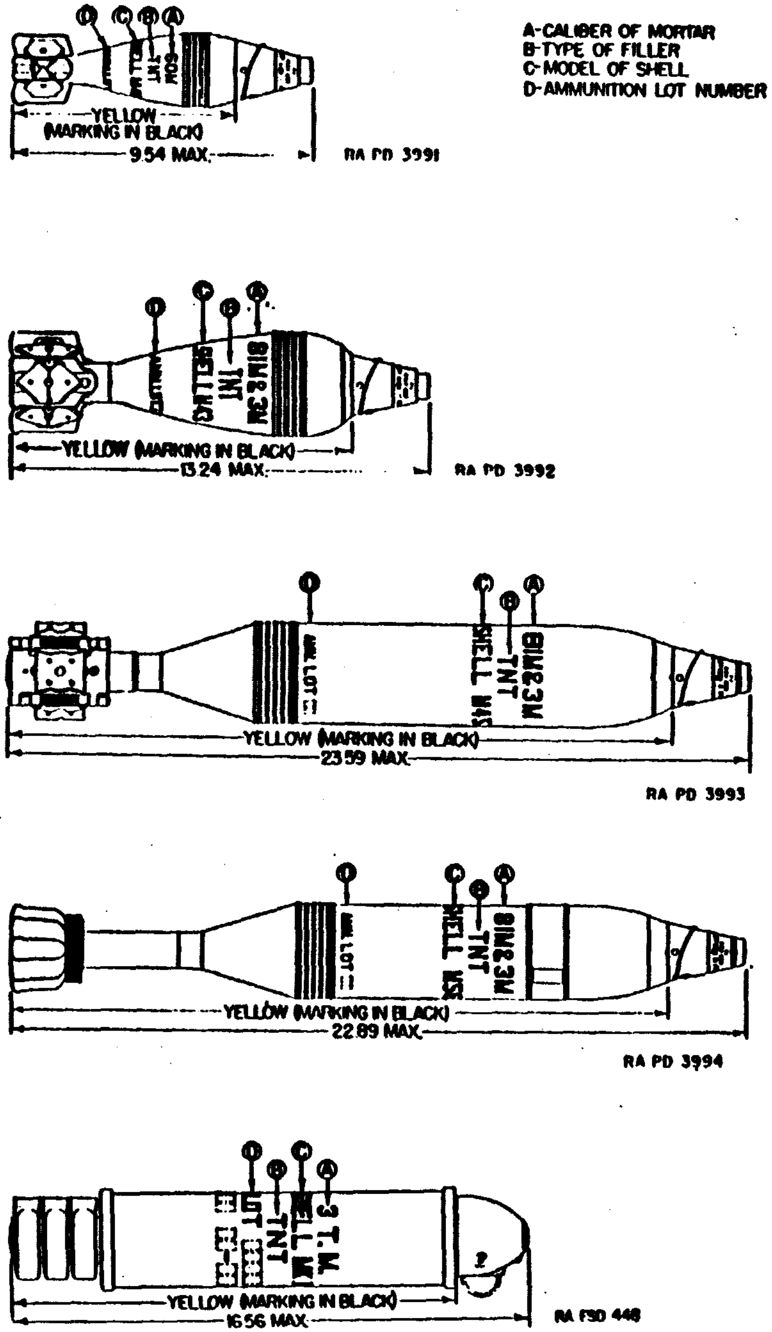


FIGURE 17. Types of mortar shell.

c. When firing, the round is inserted into the mortar, cartridge end first. When the shell is released to slide down the barrel, the hands should be promptly removed from the muzzle.

d. Duds should not be handled or moved. They should be destroyed as described in chapter 4.

75. Packing and marking.—*a. Packing.*—Ammunition of current design for 60-mm and 81-mm mortars is packed as assembled complete rounds, each in an individual fiber container and these, in turn, in bundle packings; 18 rounds of 60-mm shell per bundle, and 3 or 6 rounds of 81-mm shell, depending upon the weight. Ammunition of earlier design for 3-inch trench mortars is packed as unassembled complete rounds, 3 per box, with one extra propelling charge.

b. Marking.—In addition to the painting which identifies the ammunition as to type, the following information is stenciled on the projectiles:

(1) Caliber and type of mortar in which fired.
(2) Kind of filler.
(3) Model of shell.
(4) Ammunition lot number.

c. Further information will be found in chapters 1 and 3 and in FM 23-85 and 23-90.

SECTION V

ARTILLERY AMMUNITION

76. General.—*a. Complete round.*—The term "artillery ammunition" includes ammunition used in cannon of all calibers. It includes complete rounds and components thereof. The complete round comprises all of the components necessary to fire the cannon once. These components are, in general, the fuzed projectile, the propelling charge, and the primer. Depending upon both the type of propelling charge and the method of loading into the cannon, complete rounds of artillery ammunition are known as fixed, semifixed, or separate loading.

b. Fixed ammunition.—Complete rounds in which the propelling charge is fixed, that is, not adjustable, and which are loaded into the cannon as a unit, are known as "fixed" ammunition (fig. 18). As usually designed, the propelling charge is assembled loosely in the cartridge case, which is crimped rigidly to the projectile. The primer is fitted in the base of the cartridge case.

c. Semifixed ammunition.—Complete rounds in which provision is made for adjusting the propelling charge to the zone to be fired and which, like fixed ammunition, are loaded into the cannon as a unit, are known as semifixed ammunition (fig. 18). In the usual design of this type of ammunition, the propelling charge is divided into parts known as increments. Each such part of the charge is assembled in a bag. The full charge is assembled in the cartridge case in the base of which is the primer. The neck of the cartridge case is a free fit over the base of the projectile, hence, when it is necessary to adjust the propelling charge, the projectile is readily lifted from the cartridge case. After the unnecessary increments have been removed, the projectile is reassembled to the cartridge case and the round is loaded into the cannon as in the case of fixed ammunition.

d. Separate loading ammunition.—Complete rounds in which the separate components—projectile, propelling charge, and primer—are loaded into the cannon separately are known as "separate loading" ammunition (fig. 18). Although the propelling charge may be in one section, it is usually divided into parts with each part assembled in a bag. While rather uncommon in our service, the propelling charge may be contained in a cartridge case instead of bag, but in such instance the cartridge case is not fitted to the projectile, but is loaded into the cannon separately.

77. Classification.—Artillery ammunition is classified according to use as service, practice, blank, or drill. It is also classified according to filler as explosive, chemical, or inert.

a. Service ammunition is that which is fired for effect. It may be high explosive or armor-piercing (shell), low explosive (shrapnel), chemical (gas or smoke), or inert (canister and smaller caliber of armor-piercing shot).

b. Practice ammunition has a propelling charge but the projectile may contain a low explosive spotting charge or may be inert.

c. Blank ammunition is provided in small and medium calibers for such purposes as saluting and simulated fire. It contains no projectile.

d. Drill ammunition is provided for practice in loading and handling. It is inert.

78. Identification.—In common with other types, artillery ammunition is identified by painting, marking, and the accompanying ammunition data card. Further information will be found in paragraphs 7 and 87.

79. Projectiles.—*a. General.*—Although differing in characteristic details, all artillery projectiles are of the same general shape, that is, they have a cylindrical body and an ogival head. The principal characteristic differences are—

(1) Location of fuzes—point or base.

(2) Radius of ogive—smaller for low, larger for high velocity projectiles.

(3) Rotating band—narrow for low, wide for high velocity.

(4) Base—"boat-tailed" or "square base."

(5) Armor-piercing cap—used only with armor-piercing projectiles.

(6) Windshield or false ogive—where required for improved ballistics.

b. Components.—A projectile with principal parts named is shown in figure 20. These parts are described below.

(1) *Ogive.*—The curved portion of the projectile from the bourrelet to the point is called the ogive. The radius of the ogive is generally expressed in calibers, a caliber being the diameter of the bore of the gun. The radius of the ogive influences the flight of the projectile and in present designs generally varies from 6 to 11 calibers radius.

(2) *Bourrelet.*—The bourrelet is the accurately machined part, of slightly larger diameter, at the forward end of the body, which bears on the lands of the bore. The clearance between the diameter of the bourrelet and the bore diameter of a new cannon varies with the caliber from 0.005 inch for a 37-mm projectile to 0.020 inch for a 16-inch projectile.

(3) *Body.*—While applicable to the entire projectile, the term body is used to designate the cylindrical portion of the projectile between the bourrelet and the rotating band. It is machined to a smaller diameter than the bourrelet to reduce the surface in contact with the lands of the bore. Only the bourrelet and rotating band bear on the lands.

(4) *Rotating band.*—The rotating band is a cylindrical ring of copper or gilding metal, pressed into a groove near the base of the projectile. As the projectile moves forward in the bore, the rotating band is engraved by the rifling, and causes the rotation of the projectile necessary to maintain stability in flight. In addition, by completely filling the grooves, the band prevents the escape of gases past the projectile.

(5) *"Square base" and "boat-tailed."*—When the surface to the rear

of the rotating band is cylindrical, the projectile is described as having
a "square base"; when tapered or conical, it is known as "boat-tailed."
(6) *Base plug.*—To facilitate manufacture, armor-piercing projec-
tiles are designed to be closed at the base end with a heavy steel plug.
The base plug also provides a seat for the fuze and fuze plug.
(7) *Base cover.*—Projectiles containing a high explosive filler are
provided with a base cover (fig. 22)—a thin metal disk covering the
base of the shell—to prevent the hot gases of the propelling charge
from coming in contact with the explosive filler through joints or
possible flaws in the metal of the base.
(8) *Armor-piercing cap.*—The armor-piercing cap is of forged
alloy steel, heat-treated to have a hard face and relatively soft core.
On impact, the hardened face of the cap destroys the hardened surface
of the armor plate while the softer core of the cap protects the hardened
point of the projectile by distributing the impact stresses over a large
area of the head.
(9) *Windshield.*—The windshield, made of steel or aluminum, is
secured to the cap or head of the projectile to give improved ballistics.
(10) *Location of fuze.*—High explosive shell, designed for blast,
fragmentation, or mining effect against unprotected targets, require
a point-detonating fuze either of superquick or delay action. Armor-
piercing shell, designed for use against protected targets, must first
penetrate the protective armor, then explode, hence require base-
detonating fuzes either of delay or nondelay action.
(11) *Tracer.*—For observation of fire, some shell are equipped with
a tracer. In some models, the tracer is used to ignite the filler and
destroy the shell in case the shell misses the target.
c. Types of projectiles.—Classified according to type, projectiles are
known as high explosive, armor-piercing, chemical, shrapnel, canister,
target practice (including subcaliber), and drill.
(1) *High explosive shell (HE).*—These projectiles (fig. 21), are
made of steel and contain a relatively large charge of high explosive
filler. They are fitted with a base cover and usually designed for a
point-detonating fuze.
(2) *Armor-piercing projectile (AP).*—This type of projectile is
designed to penetrate armor plate and may or may not have an explo-
sive filler. An armor-piercing cap is fitted over the ogive and a wind-
shield over the cap. Those AP projectiles containing an explosive
charge have thick walls and a relatively small amount of explosive
filler. The base of explosive projectiles is closed by a base plug into
which the fuze is fitted and the whole covered by a base cover.
(3) *Chemical shell.*—Chemical shell, in general, are similar to high
explosive shell, differing principally in the manner of assembling the

adapter and burster-well, ... In some designs ... parts are ...
of the chemical filler. In some designs these parts are ...
tapered pipe threads, while in other designs these parts are ...
with straight threads or force-fit, and welded. A typical chemical
shell is shown in figure 23.
(4) *Shrapnel.*—Shrapnel (this type is shown in section in fig. 24)
is designed to function in flight and is therefore equipped with a time
fuze. The functioning of the fuze at a predetermined point along
the trajectory ignites a black powder charge in the base. This charge
projects the filler of metallic balls forward in a cone of dispersion,
without rupturing the case. Although some shrapnel are still in
service, they are almost entirely superseded by high explosive shell.
(5) *Canister.*—A canister consists of a light metal case, filled with
steel balls, containing no explosive charge. It breaks upon leaving
the muzzle of the cannon, allowing the balls to scatter.
(6) *Target-practice projectiles.*—(*a*) Cast-iron shot and sand-
loaded shell, of the same size, shape, and weight as service shell, are
provided for target practice. Some models contain a smoke-puff
charge and others are inert. (See fig. 25.)
(*b*) Subcaliber ammunition is fixed ammunition with special projec-
tiles provided for training in elevating, traversing, and sighting the
piece to which the subcaliber equipment pertains. Its advantage lies
in the fact that it is more economical and may be used in relatively
congested areas.
(7) *Drill projectiles.*—Inert projectiles and complete rounds for
training are known as dummy or drill ammunition. They are used
for training and practice in handling shell and in the service of the
piece. A typical drill projectile is illustrated in figure 26.
80. Fuzes.—*a. General.*—A fuze is a mechanical device used with
a projectile to explode it at the time and under the circumstances
desired. (See figs. 27, 28, 29, and 30.)
b. Types.—(1) Fuzes are classified according to position on the
projectile as "point" or "base."
(2) Fuzes are further classified as time, impact, or a combination
of both. Time fuzes contain a graduated time element in the form
of a compressed black powder train or a mechanism similar to a watch,
which may be set to a predetermined time, prior to firing. Impact
fuzes function on impact with the target. If the fuze is designed to
function on impact with a very light matériel target, such as an
airplane wing, it is called "supersensitive."
(3) Impact fuzes are further classified as superquick and delay,
depending upon their quickness of action.

NOTE.—The terms "superquick" and "delay" are used in reference to the action at the instant of impact, whereas "time" refers to time after the instant of firing.

(4) Depending upon the mechanism of arming, certain fuzes are considered "bore-safe," that is, the explosive train is so interrupted that, even if the more sensitive elements should function prematurely, the projectile cannot explode until after it leaves the muzzle of the cannon.

c. Arming.—In general, all artillery fuzes are in an unarmed condition prior to firing although in a strict sense time fuzes are always armed despite the mechanical restraint which prevents initiation of time action. Fuzes of the impact type are usually armed by centrifugal force acting on parts of the fuze after the projectile leaves the muzzle. The time element of time fuzes is initiated at the instant of firing by "set-back" (see app. I). To prevent accidental arming during handling and shipping, safety devices such as a safety wire or cotter pin are used when required. Such safety devices are to be removed prior to firing.

81. Adapters and boosters.—*a. Adapters.*—An adapter is a steel bushing fitted to the nose of a shell and threaded to receive the fuze.

b. Boosters.—The term "booster" is applied to one of the explosive elements in the bursting charge explosive train. It consists essentially of the booster explosive in a metal case. In some designs the booster is a part of the shell loading assembly, in others it is assembled to the fuze as shipped. Tetryl is the most commonly used booster explosive. The corresponding explosive element in chemical shell which opens the shell and disperses the chemical agent is called a "burster."

c. Adapter-boosters.—When a booster is assembled to an adapter, the combination is known as an adapter-booster. In general, adapters and boosters are components assembled to the shell or fuze at the time of manufacture and are not shipped separately for assembly in the field.

82. Propelling charges.—*a. General.*—In general, propelling charges (figs. 18 and 32) consist of a charge of smokeless (NH or FNH) powder, with an igniter charge of black powder, assembled in a suitable container. The powders used as propellants are described in section III, chapter I. The nature of the container depends upon the design of the ammunition. In the case of small-arms and fixed ammunition, the cartridge case, crimped rigidly to the bullet or projectile, serves as the container for the charge, which is assembled loosely therein. In semifixed artillery ammunition, the charge, being divided into parts or increments for zone firing, is assembled with each increment in a cloth bag. The full charge, with all increments in proper order, is assembled in the cartridge case which, for this kind of ammunition, is a free fit over the end of the projectile. In semifixed mortar ammunition, the increments, consisting of bundles of sheet powder, are nested between the blades of the fins. The ignition

cartridge contains the igniter charge. In small-arms ammunition, the fire from the primer is adequate to ignite properly the small grains of the propellant, hence an igniter is not required. In fixed and semifixed ammunition, the igniter charge of black powder is contained in the outer end of the artillery primer which is fitted into the base of the cartridge case. In separate loading ammunition the propellant and the igniter are assembled in cloth bags. Depending upon the design of such charges, they are known as single section or multisection charges (fig. 32). Multisection charges are subdivided into "base and increment," "equal section," and "unequal section" types. Separate loading propelling charges, which are shipped and stored in cartridge storage cases (fig. 39), are further described below.

b. Single section charge.—In this type of charge (fig. 32), the propellent powder is contained in a single bag, tightly laced to give the charge rigidity. The igniting charge is divided into three parts, each in its own bag—two end pads and a core which extends axially through the center of the charge and connects the igniter pads sewed to each end.

c. Base and increment charge.—Charges of this type (fig. 32) have a base section and one or more increments. The increments may be of equal or unequal weights, but usually weigh less than the base section. With some types, one igniter pad is attached to the base end of the base section only, while other types have a core igniter running through the center of the base and each increment, with an igniter pad at the base end of the base section. Others have, in the base section only, a core igniter connecting an igniter pad on each end.

d. Equal section charge.—This type of charge (fig. 32) is also known as an "aliquot part charge." As the name implies, these charges are divided into a given number of equal sections. In those designs in which the igniter pad is separate, tying straps are provided for attaching the igniter to the propellent charge. In other designs the igniting charge is divided into parts, having an igniter pad at the base end of each section. In other types there is a longitudinal core igniter connecting with an igniter pad on each end of each section.

e. Dummy charge.—Dummy charges, simulating service charges, are provided for use with drill projectiles for the purpose of training personnel in the service of the piece.

f. Cartridge bags.—Silk has been found to be the most satisfactory material for cartridge bags, although wool, mohair, or cotton may serve as a substitute for lower grades of silk.

g. Color.—(1) In cases where two types of propelling charges are designed for one cannon—one for inner, the other for outer zones of fire—the cloth of the bags for the inner zone is dyed green to distinguish that charge from the other type which is assembled in undyed (white) bags.

(2) Bags of current manufacture used for the igniter charge are dyed red to indicate the presence of the black powder igniter. Those of earlier manufacture (undyed) are marked "IGNITER."

83. Cannon primers.—*a. General.*—A cannon primer, commonly called a "primer," is the component used to initiate the ignition of the propelling charge. Although made in various forms, it consists essentially of a small quantity of sensitive explosive and a larger quantity of black powder, encased in a metal container. The method of firing the sensitive explosive element and the quantity of black powder used depend upon the design of the propelling charge (fig. 35). In the case of fixed and semifixed ammunition, the primer (fig. 18) is in the form of a tube having a slightly enlarged head which is forced into the base of the cartridge case. In the case of separate loading ammunition, the primer is designed for insertion into the breechblock and is fired by percussion, friction, or an electric current. Based on the method of firing, cannon primers are classed as—

Percussion.
Friction.
Electric.
Combination percussion-electric.
Igniting.

b. Percussion primer.—This type of primer (fig. 36), designed to be fired by a blow of the firing pin, is generally used with all artillery ammunition except that for harbor defense and railway artillery. The primers used in cartridge cases contain sufficient black powder to ignite properly the smokeless powder in the cartridge case. Those used with separate loading propelling charges contain only enough black powder to ignite the black powder igniter attached to the propelling charge.

c. Friction primer.—This type of primer (fig. 36) is fired by the heat generated when a serrated plug is pulled through an explosive composition sensitive to heat or friction. At the present time it is used as a substitute for the electric primer in the event of failure of electric power.

d. Electric primer.—This type of primer (fig. 36) is fired by the heat generated when an electric current passes through a resistance wire embedded in a sensitive explosive composition. It is used only in harbor defense and railway artillery. Although both the friction and electric primers are very similar, the electric primer is distinguished by black insulation around the wire.

e. Combination percussion-electric primer.—This primer (fig. 36) is designed to be fired either electrically or by a blow of the firing pin. It is used only in certain harbor defense and railway artillery.

f. Igniting primer.—This type of primer, although very similar to the percussion type, differs therefrom in that it contains an inert cap with a hole in it, in lieu of the percussion element. It is intended for use in certain subcaliber ammunition which is designed to be fired by a service primer. The flame from the service primer passes through the hole in the cap of the igniting primer, thus igniting the black powder charge in the igniting primer.

84. Igniters.—In the propelling charge explosive train, the igniter is the explosive (black powder) which intensifies the spit from the primer composition to the end that the propellent powder is ignited properly. The term "igniter" is more commonly used in referring to the igniter charge in the form of "pads" or "cores" attached to, or used with, separate loading propelling charges. The bags of such pads or cores of later manufacture are made of red cloth to distinguish them from the bags containing the propellent powder. (See figs. 33 and 34 and par. 82.) Prior to packing in a cartridge storage case, a cloth or paper "igniter protector cap" is placed over the igniter ends of separate loading propelling charges for protection during shipment and storage. Igniter protector caps must be removed prior to loading the charge into the cannon.

85. Blank ammunition.—*a. General.*—Blank ammunition is provided for cannon of caliber up to and including 105 mm, for practice purposes, for maneuvers, for firing the morning and evening gun, and for saluting. The regulations governing use of blank ammunition may be found in AR 210-10, AR 600-25, AR 600-30, and section II, Circular No. 218, War Department, 1941.

b. Complete round.—The complete round of blank ammunition consists of a cartridge case with primer, a charge of black powder, a felt wad, and a closing cup sealed in the mouth of the case. The cartridge case is usually made by trimming the service cartridge case to a suitable length. A typical round of blank ammunition is illustrated in figure 37.

86. Care and precautions in handling.—*a.* In addition to the precautions prescribed in chapter 8, the following will be observed:

b. Ammunition, especially the rotating bands and cartridge cases, will be protected from such damage as would affect their serviceability. A damaged rotating band will affect the flight characteristics of the projectile; a dented cartridge case may jam in the chamber.

c. The seals of airtight containers will not be broken until the ammunition is to be used, except as required for inspection.

d. Components containing sensitive explosives such as fuzes, primers, and detonators will be protected from undue shock and high temperature.

c. No attempt will be made to disassemble fuzes in the field without specific instructions from the Chief of Ordnance.

87. Packing and marking.—*a. Packing.*—Except for calibers smaller than 75 mm, which are packed in a metal-lined box, fixed and semifixed ammunition is packed as assembled complete rounds in individual fiber or metal containers which are bundled or boxed (fig. 40). Separate loading ammunition is packed separately as follows:

(1) Unfuzed high explosive projectiles—with grommet to protect the rotating band, and eyebolt lifting plugs (fig. 23).

(2) Projectiles such as armor-piercing, having a windshield or false ogive—in a crate or box (fig. 41).

(3) Separate loading propelling charges—in airtight metal cartridge storage cases (fig. 39).

(4) Primers—in sealed metal or moisture-resistant containers and these, in turn, in metal-lined boxes (fig. 42).

(5) Fuzes with or without boosters—in individual waterproof or moisture-resistant containers and these, in turn, in wooden or metal-lined boxes.

b. Marking.—Artillery ammunition, in common with other types, is identified by the painting and marking and the accompanying ammunition data card (par. 8). The basic color scheme—yellow, high explosive; red, low explosive; gray, chemical; blue, practice; black, drill—applies also to artillery ammunition. However, there are now on hand target practice projectiles of larger caliber which have been painted black. It is contemplated that when replacement or repainting is required, they will be painted blue in agreement with the basic color scheme. Armor-piercing projectiles which contain a high explosive filler are painted yellow; those too small to have a high explosive filler and fuze are painted black. The marking on the projectile includes—

Caliber and type of cannon in which fired.
Kind of filler (TNT, WP smoke, etc.).
Mark or model of projectile.
Weight zone marking.
Lot number.

Similar information is marked on other components. For examples of typical markings see figures 19, 23, 31, and 38. Further information will be found in the Technical Manuals and Field Manuals pertinent to the particular type and caliber of ammunition and weapon.

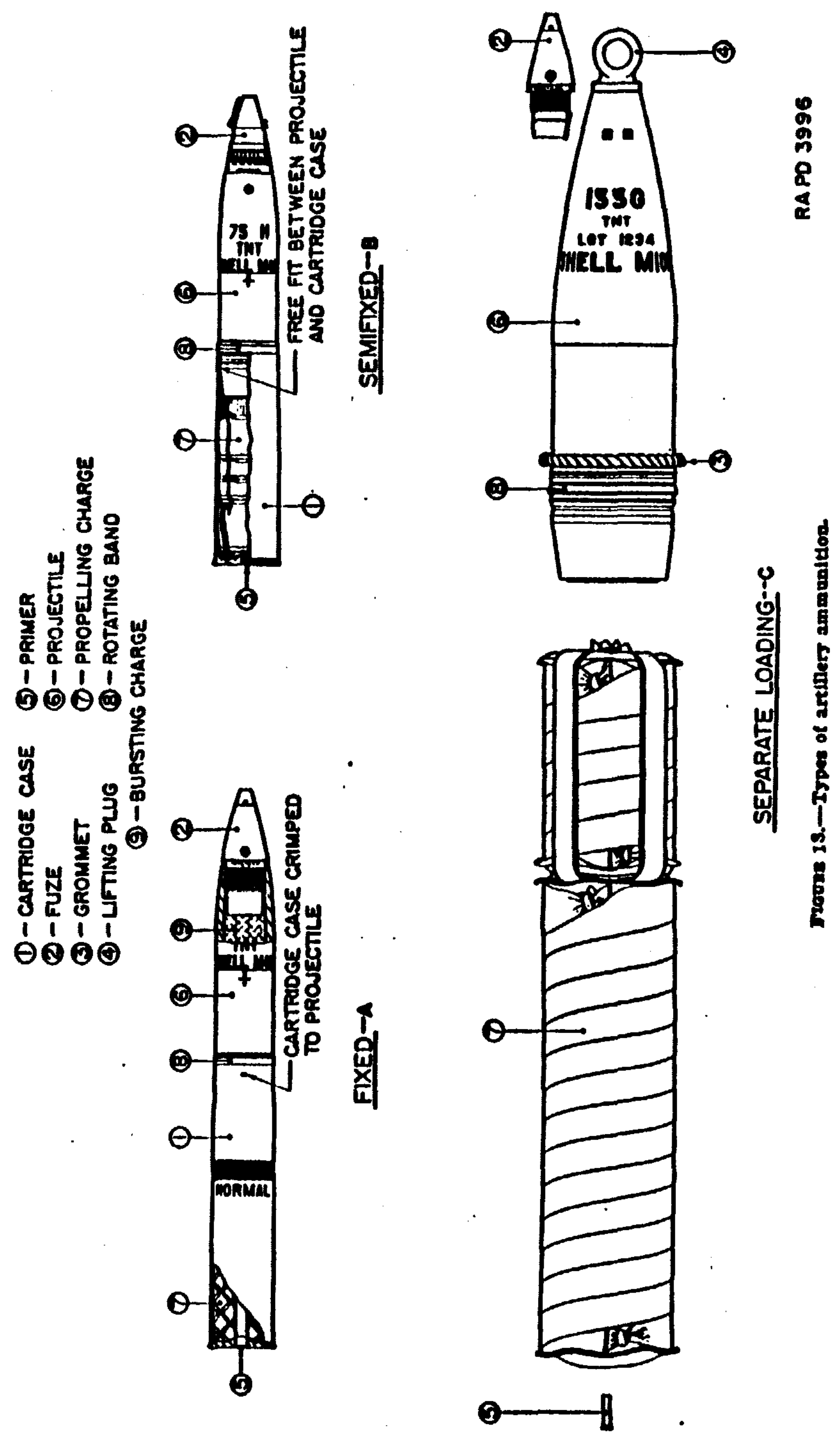


Figure 13.—Types of artillery ammunition.

AMMUNITION DATA CARD

Kind: Round, Complete, Shell, H. E., M1 (with M48 P. D. Fuze) for Howitzer 105 mm, M2 — Amm. Lot No. 3319-[illegible]
Card No. [illegible]
Quantity in Lot
Date Feb 1941
Complete Round Dwg. 73-1-13 [illegible] — PXS [illegible] (Rev. [illegible])
Assembled by [illegible] Arsenal
Expected muzzle Velocity 1550 F. S. — Pressure 27,100 lbs. per sq. in.
Wt. of Propelling Charge 40 ozs. — Projectile weight [illegible] lbs. as fired approx. [illegible]
Contract No. Ord. 3319 — P. A. F. O. [illegible]

Zone	Wt. Chg. By Zone (ozs.)	Total Wt. Chg. (ozs.)	Muzzle Velocity	Pressure
1	[illegible]	[illegible]	[illegible]	
2	[illegible]	[illegible]	[illegible]	
3	[illegible]	[illegible]	[illegible]	
4	[illegible]	[illegible]	[illegible]	
5	[illegible]	[illegible]	[illegible]	
6	[illegible]	[illegible]	[illegible]	
7	[illegible]	[illegible]	1550	27,100

Packed 2 per box

Remarks

COMPONENTS

Data	Cartg. Case	Primer Perc.	Powder	Projectile	Filler	Fuze	Booster
Kind	M14	M1B1A1	Smk., FNH M1	H. E. 105 mm M1	TNT Flaked	P. D. M48	M20
Manuf.	P. A.	P. A.	duPont	P. A.	duPont	P. A.	P. A.
Lot No.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3319-[illegible]	3319-1
Year Mfg.		1940	1940		1941	1940	1940
Date Filled	1941			1941			
Method	Zone Charge			Cast			
Dwg. No.	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]
Rev. Date	[illegible]	[illegible]		[illegible]		[illegible]	P. F. [illegible]

Certified to by: J. Johns Jr., Inspector

Note: See Instructions on Reverse Side of Card.

RA PD 4015-A

(1) Obverse.

INSTRUCTION CARD

To set fuze for superquick action.—Turn the setting sleeve so that the screw driver slot is in line with "S. Q." stamped on the ogive.

To set fuze for delay action.—Turn the setting sleeve so that the screw driver slot is in line with "Delay" stamped on the ogive.

To prepare the round for zone firing.—To fire the round in the highest zone, no change is required. To fire the round in a zone other than the highest, remove the projectile from the cartridge case; invert the cartridge case so that the increments will fall out. Break the twine and remove the increments marked with higher numbers than the zone in which the round is to be fired. Replace the remaining increments in the cartridge case so that the bags and loose ends of the twine are well down in the case. Replace the projectile in the cartridge case. NOTE: SEE DATA ON REVERSE SIDE OF CARD.

RA PD 4015-B

(2) Reverse.

Figure 19. Ammunition data card.

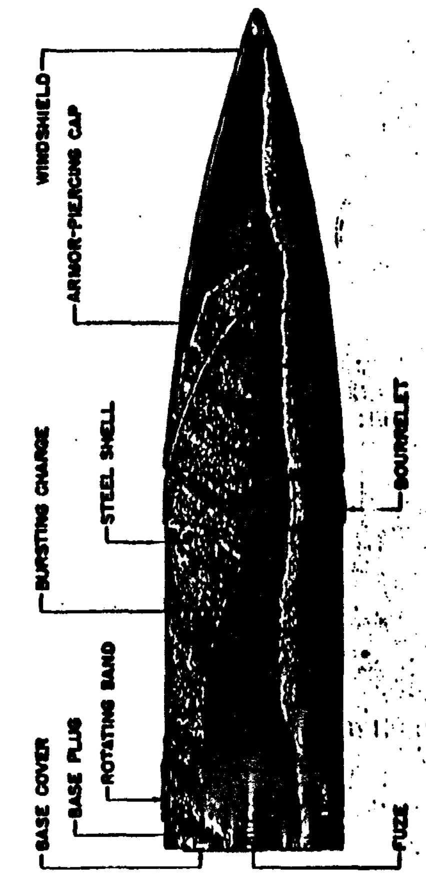


Figure 20.—Armor-piercing projectile.

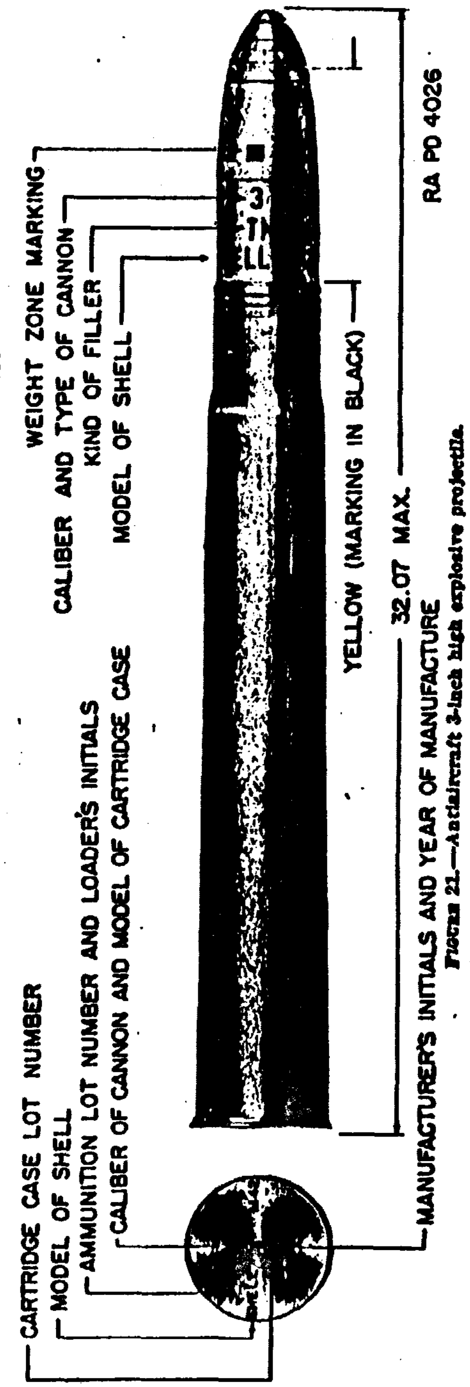


Figure 21.—Antiaircraft 3-inch high explosive projectile.

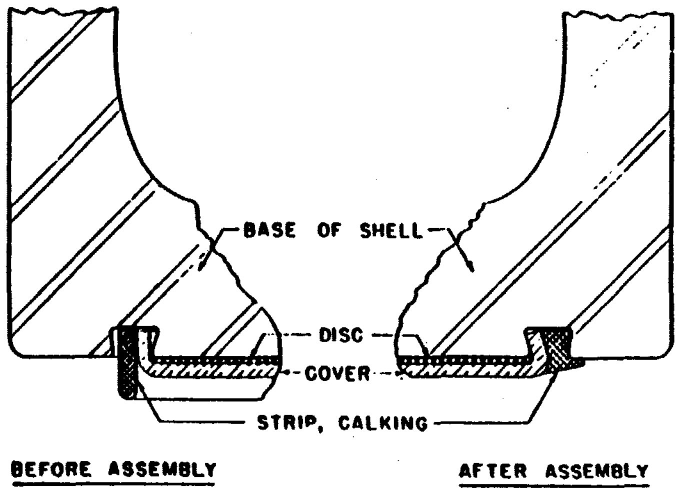


Figure 22.—Base cover detail.

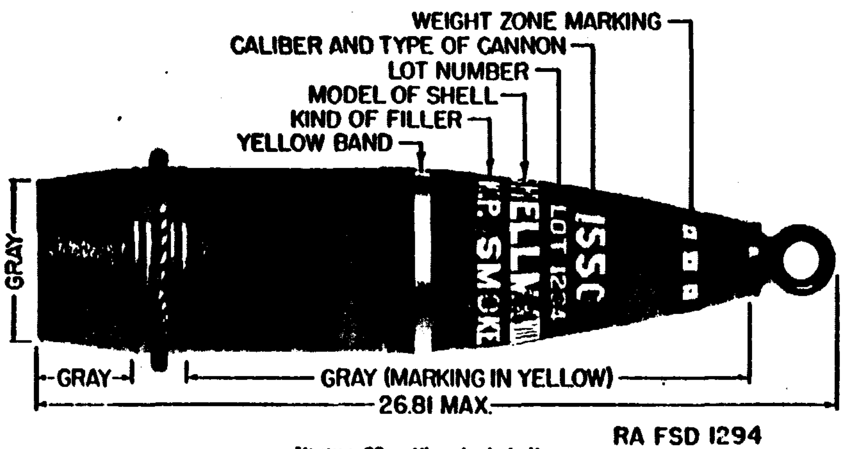


Figure 23.—Chemical shell.

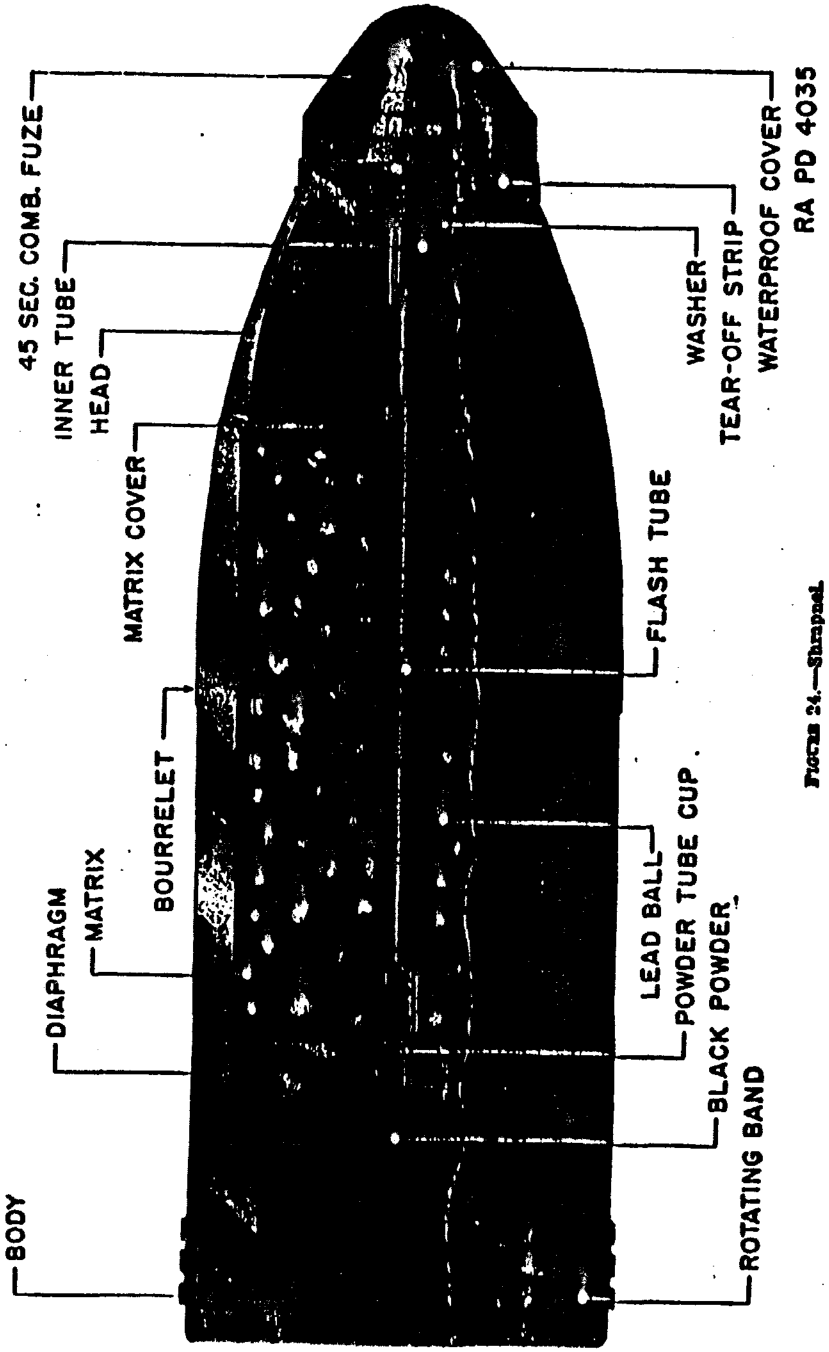


Figure 24.—Shrapnel.

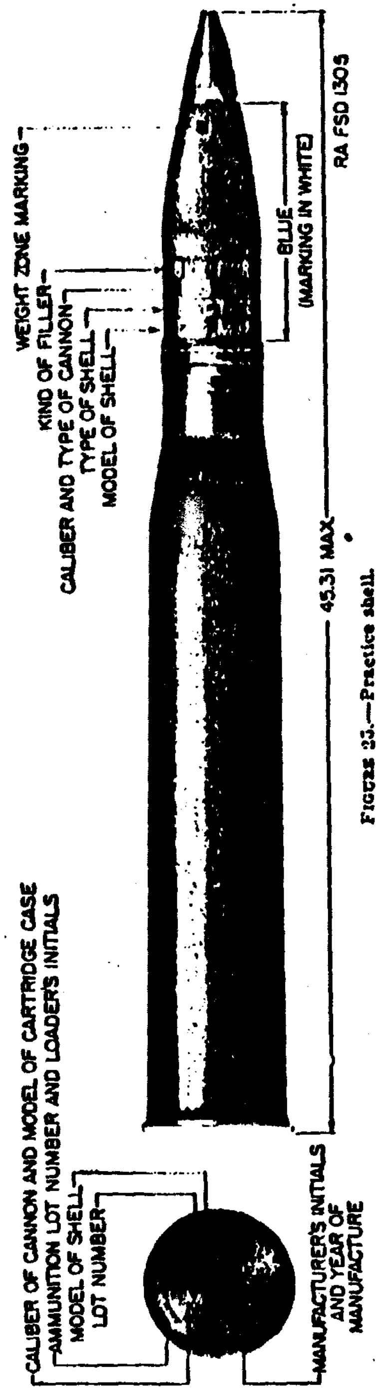


Figure 25.—Practice shell.

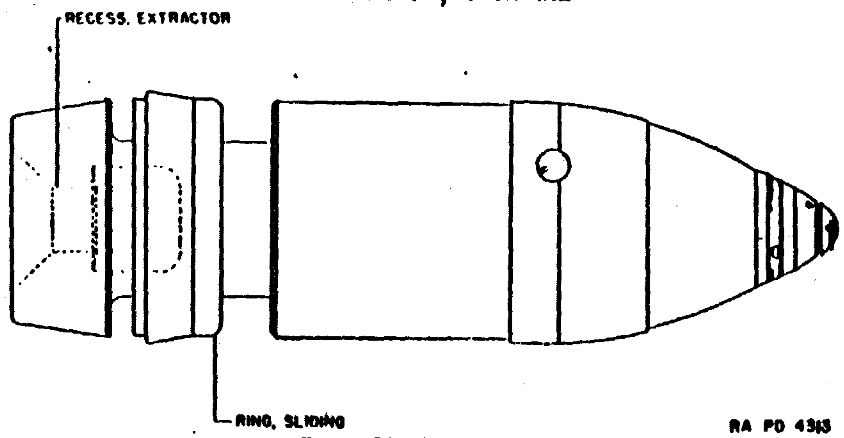


Figure 26.—Dummy shell.

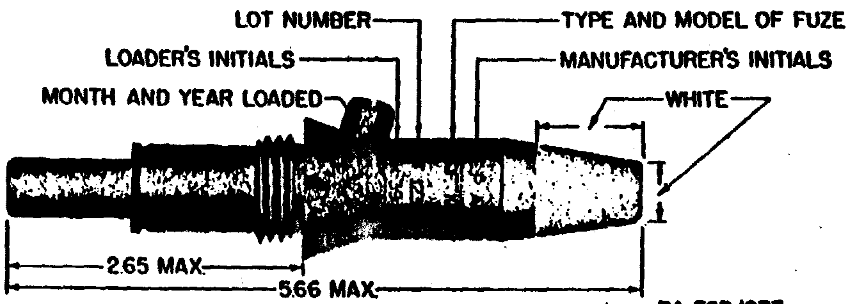


Figure 27.—Fuze, point-detonating, M46.

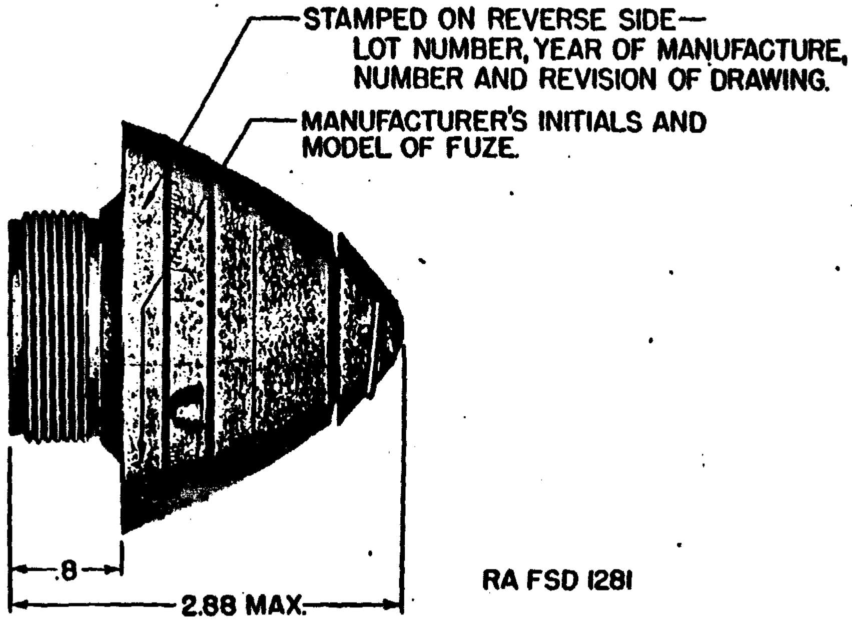


Figure 28.—Fuze, time, 45-second, M1907M.

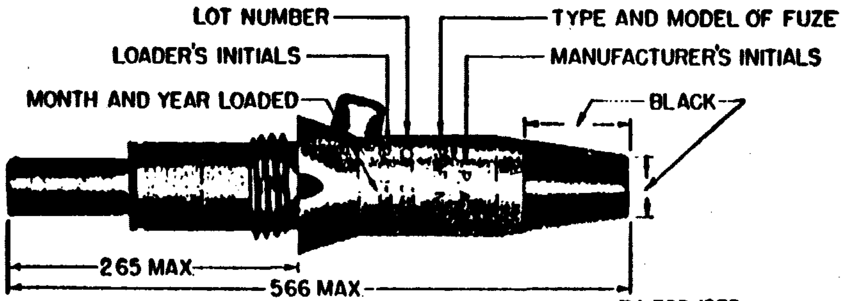


Figure 29.—Fuze, point-detonating, M47.

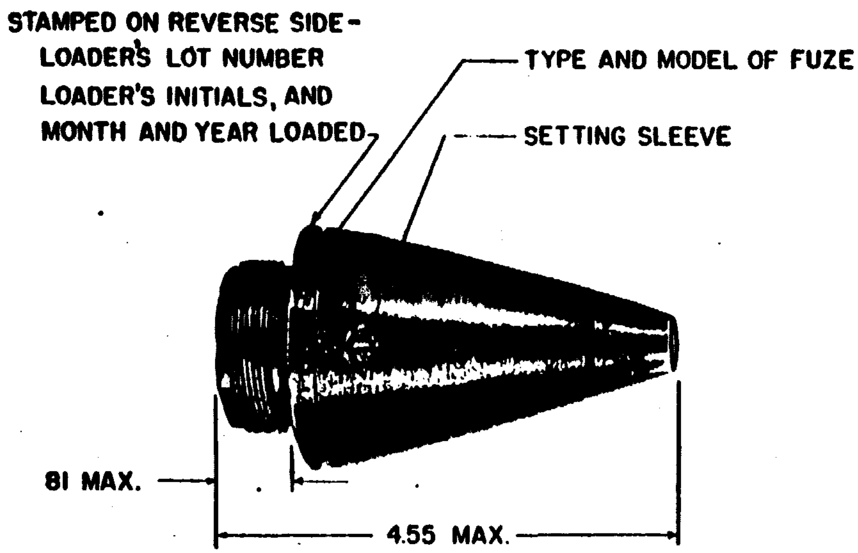


Figure 30.—Fuze, point-detonating, M48.

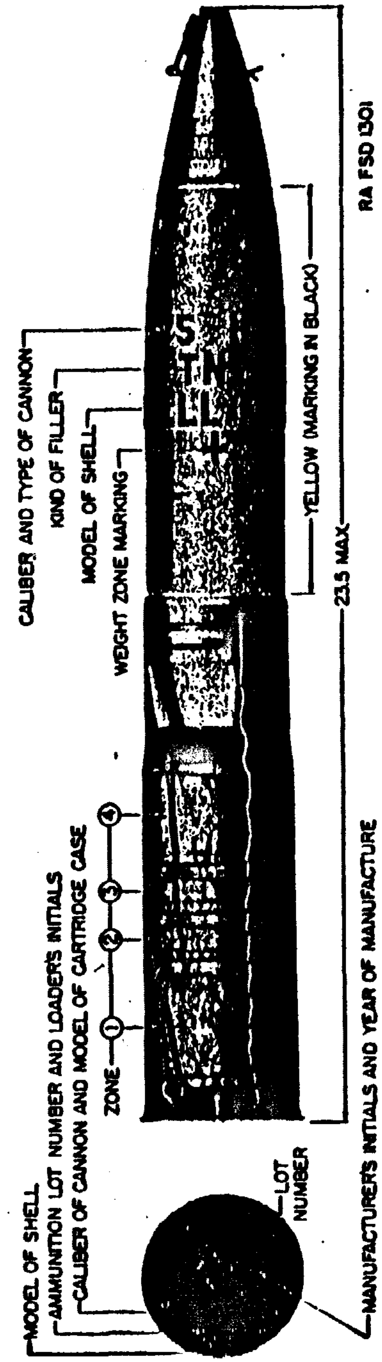


Figure 31.—Semifixed ammunition.

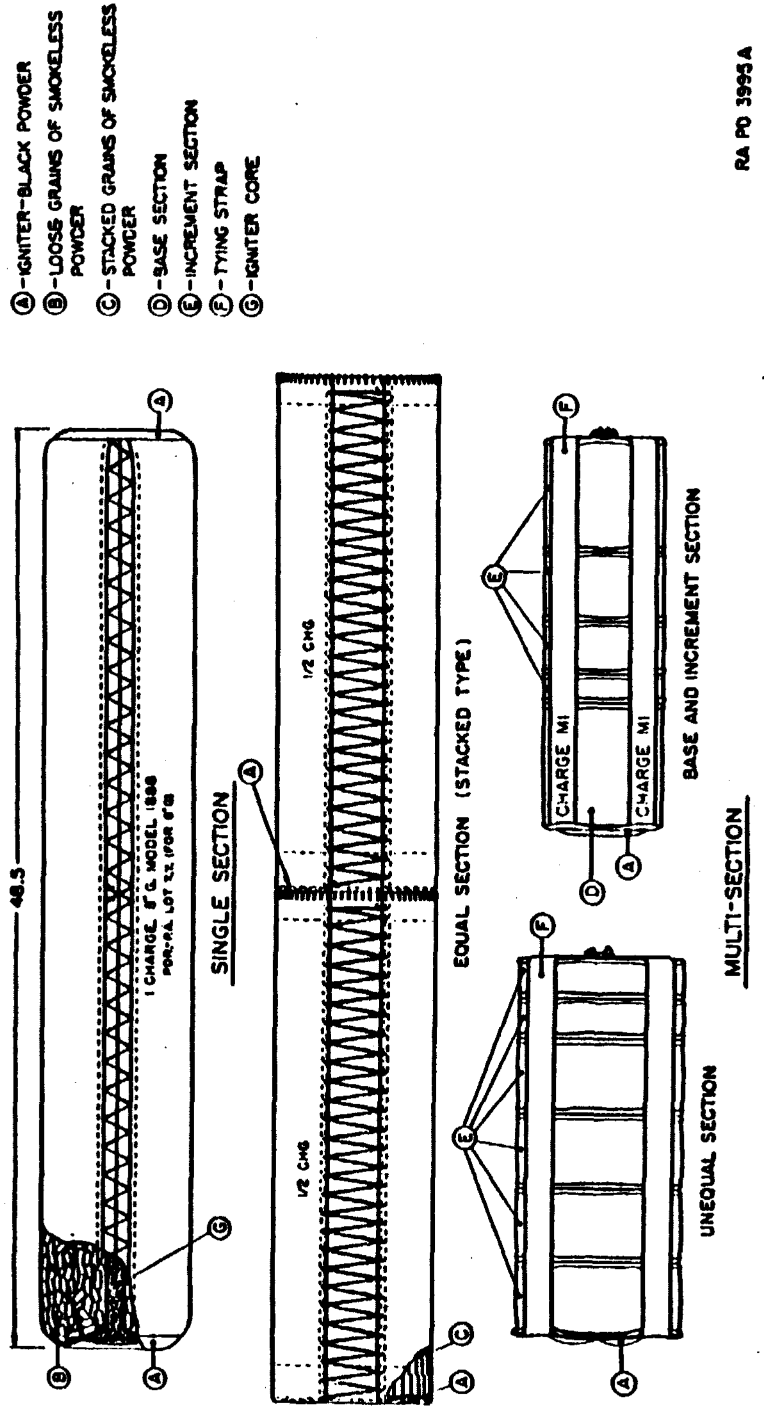


Figure 32.—Propellent charges.

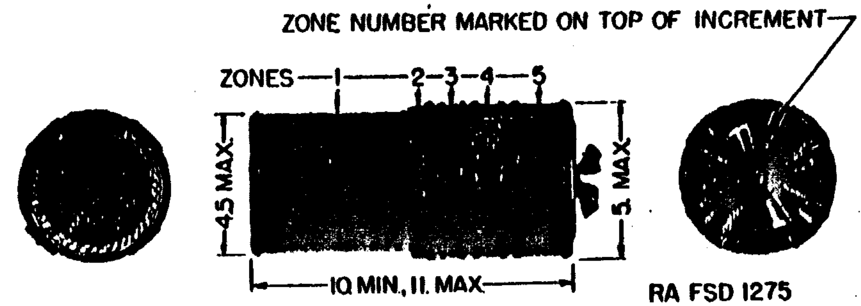


Figure 33.—Propellant, green bag, M1A1.

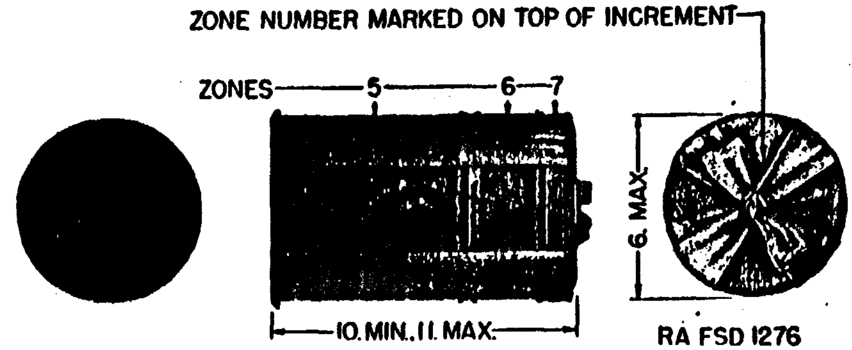


Figure 34.—Propellant, white bag, M2.

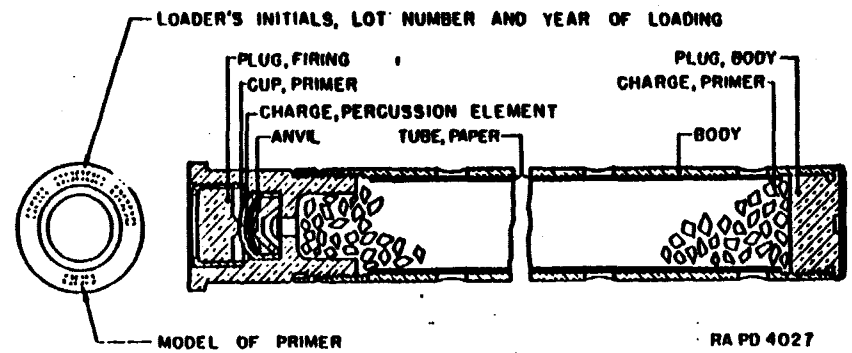


Figure 35.—Typical primer.

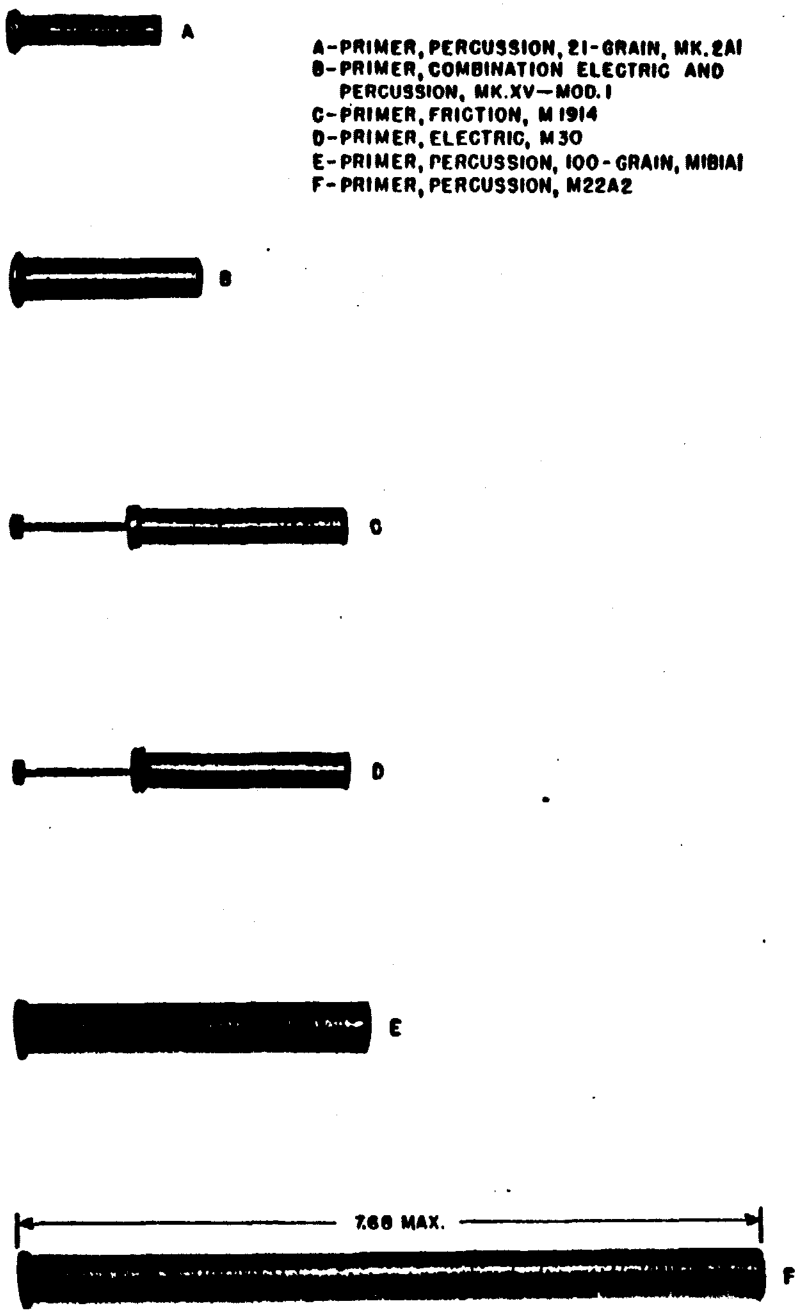


FIGURE 36.—Artillery primers.

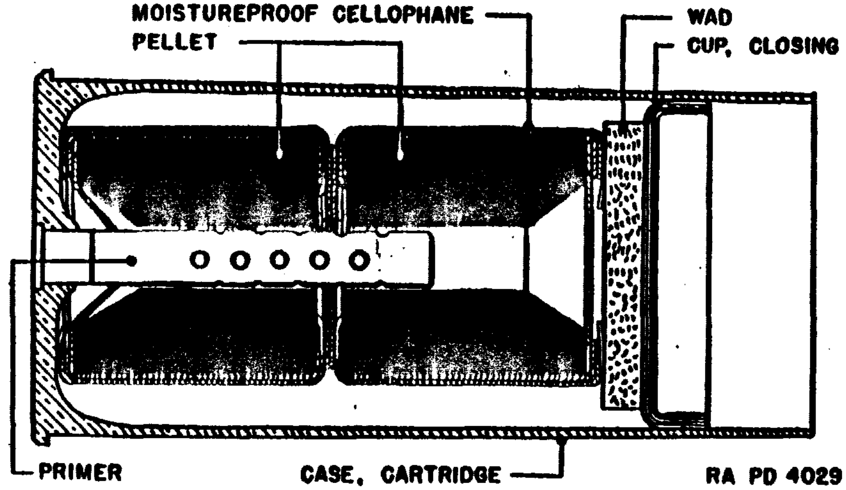


FIGURE 37.—Double pellet blank ammunition.

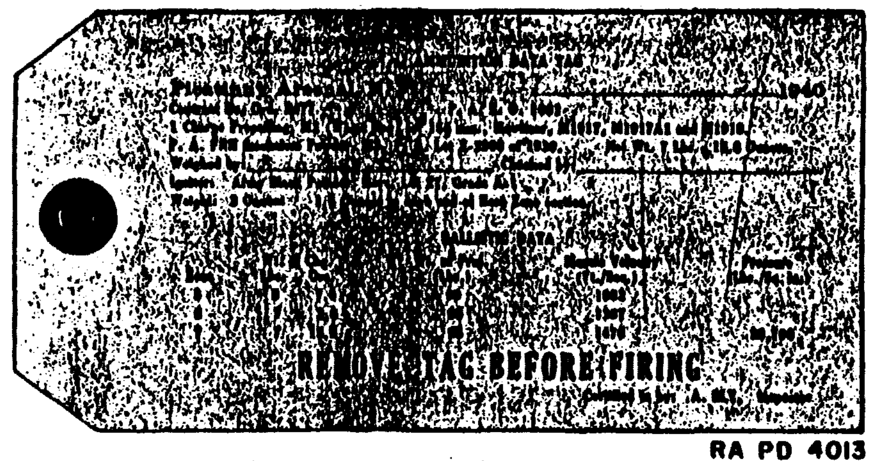


FIGURE 38.—Propelling charge data tag.

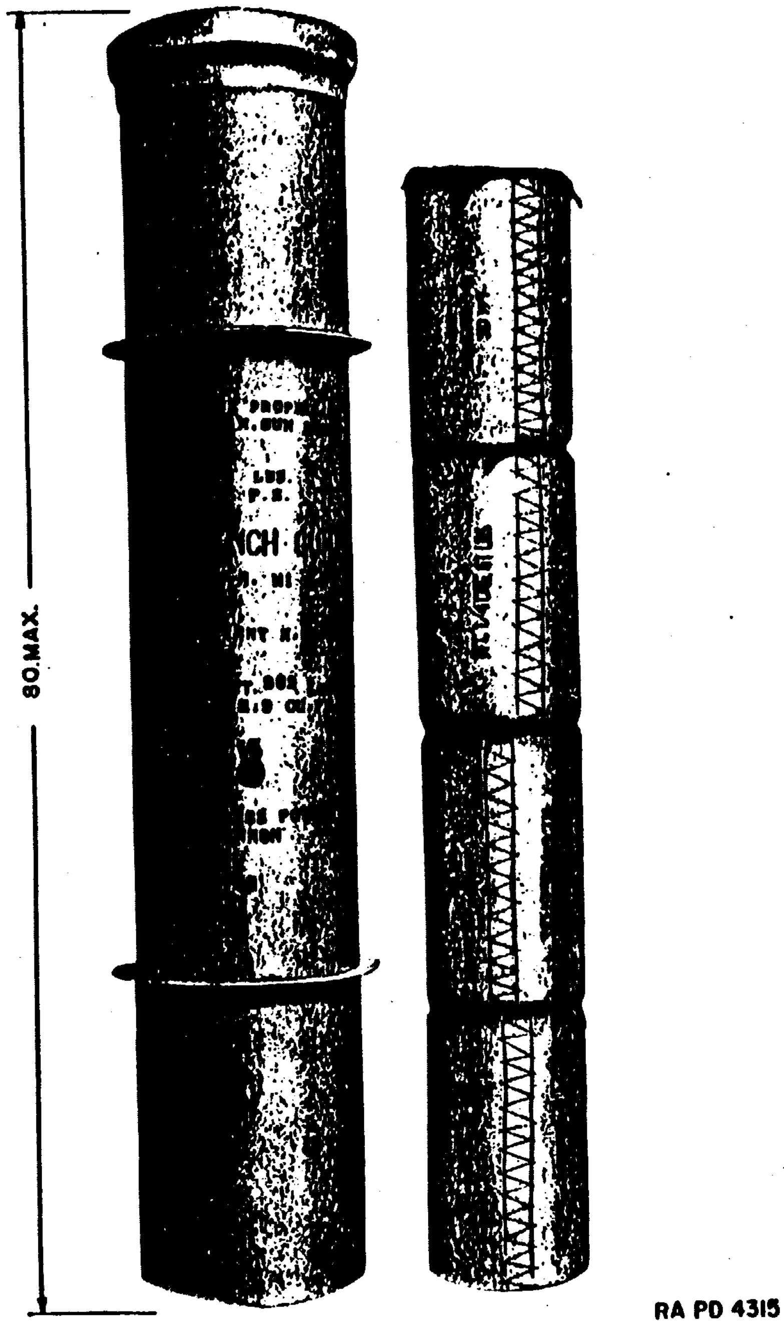


FIGURE 39.—Cartridge storage case and charge.

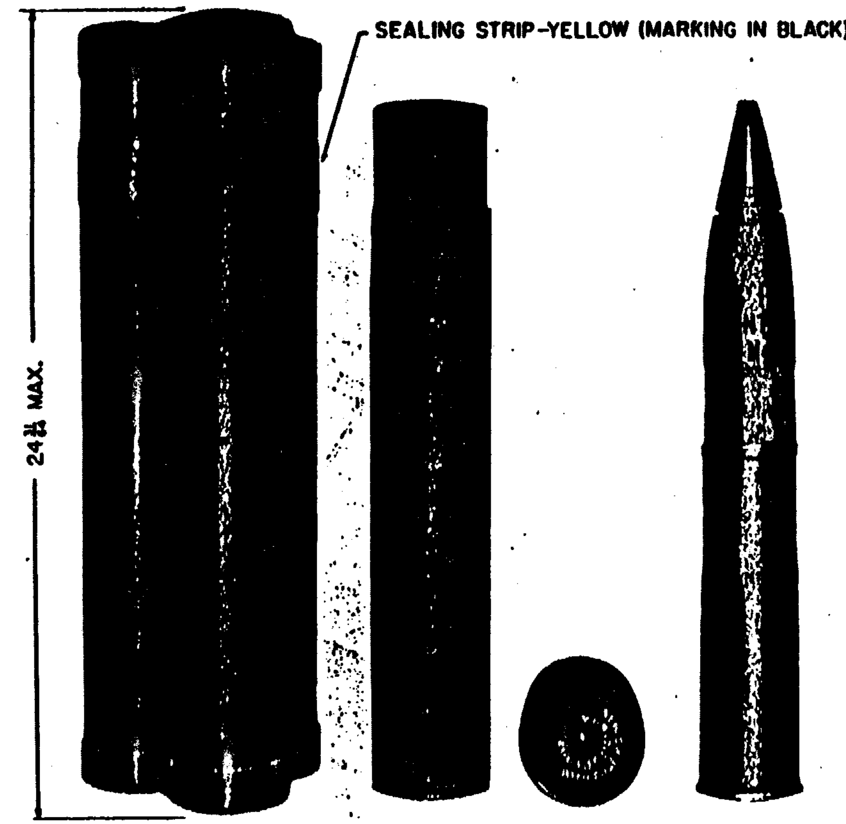
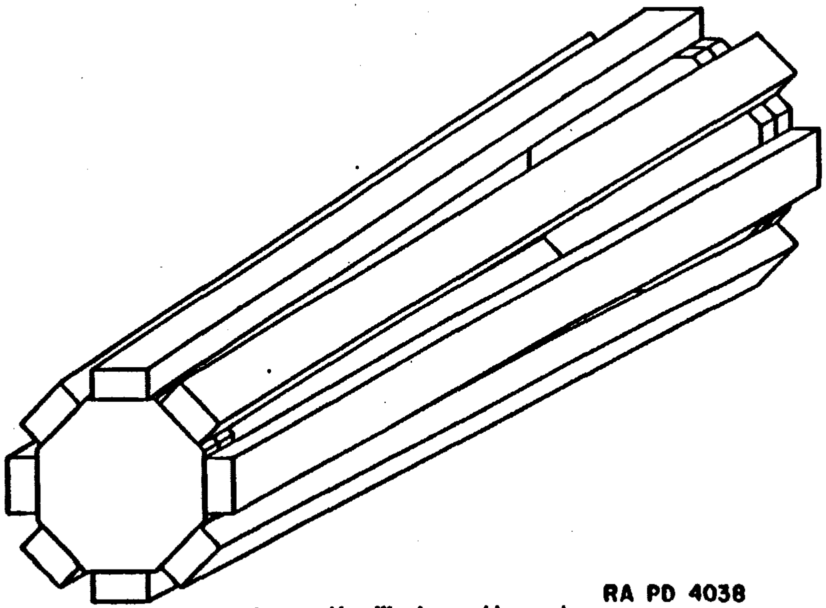
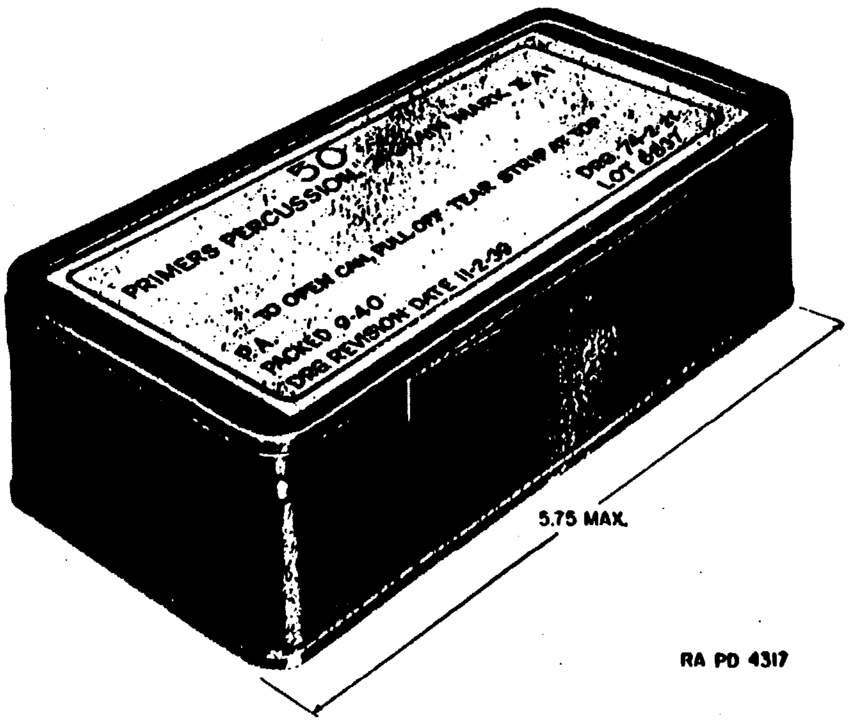


FIGURE 40.—Bundle packing.



RA PD 4038

Figure 41.—Wooden packing crate.



RA PD 4317

Figure 42.—Primer packing can.

Section VI

BOMBS

88. General.—*a.* Bombs are missiles designed for release from airplanes. For reasons of safety they are usually stored and shipped as separate components. For use in the field they are issued as unassembled complete rounds which must be assembled prior to use. (See also par. 98 and ch. 8.) While the components of bombs differ, depending on the particular type and model, in general they consist of—

(1) The unfuzed bomb, with or without fin assembly.

(2) The fuze or fuzes.

(3) The fin assembly (for smaller bombs, assembled to bomb as shipped).

(4) The arming wire assembly.

These components for a complete round demolition bomb are shown in figure 45.

b. Bombs are installed in airplanes by means of suspension lugs on the side or tail of the bomb. Bombs of 100 pounds and heavier have two suspension lugs on the side of the body arranged for horizontal suspension of the bomb. Smaller bombs have one lug on the side and another on the tail end, thereby permitting the bomb to be installed either in a horizontal or vertical bomb rack.

c. The functioning of bombs is dependent primarily upon the action of the fuze fitted thereto—superquick, delay, or time. The terms superquick and delay are used in reference to the action at the instant of impact, whereas time refers to time after release.

d. Bomb fuzes are prevented from arming or functioning by means of an arming wire which is normally removed by the bomb's release from the airplane. When it is necessary to remove the arming wire to unfuze a bomb, instructions attached to the fuze will be carefully followed. Provision is made for releasing the bomb from the airplane without removing the arming wire from the fuze when it is desired that the bomb should land without functioning.

c. A brief description of the several types of bombs is included in the following paragraphs. For complete details of the various types and models, see TM 9-1980.

89. Classification and identification.—*a.* Depending upon the kind of filler, bombs may be classified according to purpose as demolition, fragmentation, or practice. Practice bombs are provided for training and marksmanship; they may have a low explosive spotting charge or they may be inert. Drill bombs, which are inert, provide for training and assembling (fuzing) and handling the complete round.

b. Bombs, in common with other types of ammunition, are identified by the painting, marking, and the accompanying ammunition data card. With one exception, the same basic color scheme which identifies all ammunition as to kind of filler (par. 8) is used for bombs. The marking on the bomb identifies it as to type, weight, model, filler, lot number, loading plant, and date loaded. Representative markings are shown in figures 47 and 48.

90. Demolition bombs.—*a.* These bombs are designed for the destruction or demolition of matériel targets, the destructive effect being produced chiefly by the violence of the detonation, although fragments may cause additional damage, particularly when the detonation occurs above ground. The walls of such bombs are relatively thin and the explosive filler is almost 50 percent of the total weight of the bomb. A blast effect is obtained by using a fuze designed for superquick action; a mining effect, by a delay action fuze. Standard demolition bombs are made in sizes ranging from 100 to 4,000 pounds and are designed to use both nose and tail fuze (fig. 43). Except for the 100-pound size, the fins are shipped separately (fig. 47). The bodies of demolition bombs of current design are cylindrical; those of earlier design were streamlined. Figure 44 shows a typical demolition bomb as a complete round; figure 45 shows the bomb as shipped but with packings removed; figure 46 shows the packing crate.

b. General purpose bombs are demolition bombs modified for use by all arms and services.

91. Armor-piercing bombs.—These are designed for piercing the armor of warships and other similarly armored targets and concrete protective targets. They are of heavier construction than demolition bombs and contain a relatively smaller percentage of explosive filler. They are designed for tail fuzes of the time delay type.

92. Fragmentation bombs.—*a.* Fragmentation bombs are designed for use against personnel and light matériel targets such as motor transport and airplanes, the principal destructive effect being produced by fragments of the bomb body projected at high velocity, the fragments weighing 0.2 to 0.3 ounces each. Bombs weighing 20 to 30 pounds and having relatively thick walls produce the most effective fragments. The explosive filler weighs approximately 15 percent of the total weight of the bomb. Tail fins are used to stabilize the flight of all bombs except those used for special purposes such as low altitude bombing, in which case a parachute is used to retard the flight of the bomb until the airplane has cleared the danger area. Fragmentation bombs are designed for nose fuze only. Fragmentation bombs are packed as unassembled complete rounds in wooden boxes, metal crates, or bundle packings. Typical fragmentation bombs are shown in figure 48.

b. Small fragmentation and incendiary bombs are assembled in clusters (fig. 49) for more effective use and for ease in handling and dropping. Cluster adapters support the individual bombs and in turn are hung on the large size bomb racks. The cluster is dropped from the airplane as a unit. The arming wire acts to release the bombs from the adapter, either by mechanical means directly or by firing a cartridge which causes their release.

93. Chemical bombs.—Bombs containing chemical agents which produce a toxic or an irritating physiological effect, a screening smoke, an incendiary action, or any combination of these, are termed chemical bombs. They are known as gas, smoke, or incendiary, depending upon the principal effect. The force necessary to open the bomb body and properly disperse the chemical agent is provided by an explosive element called a burster. As the body need serve only as a container for the chemical agent, the walls are very thin and the proportion of filler to total weight is very large. Chemical bombs are authorized in 4-, 30-, and 100-pound sizes. Fuze action is superquick to prevent the waste of any of the charge by its being carried underground. Chemical bombs are packed finned, but without fuze and burster, in wooden boxes. A typical chemical bomb is shown in figure 50.

94. Practice bombs.—Practice bombs are provided for training in marksmanship. They may be sand loaded at point of use and they may contain a low explosive spotting charge which for some uses, such as against water targets, may be omitted. Such bombs are designed to simulate corresponding service bombs of the fragmentation and demolition types. A typical practice bomb, one which simulates the demolition type, is shown in figure 51.

95. Drill bombs.—Drill bombs are provided for training in assembling (fuzing) and handling operations. They are the same size and shape as standard demolition bombs, ranging in weight from 100 to 2,000 pounds. All components are inert.

96. Fuzes.—*a. Types.*—Bomb fuzes are classified according to method of arming as—

(1) Arming-vane type.
(2) Arming-vane type with mechanical delay.
(3) Arming-pin type.
(4) Arming-pin type with time delay.
(5) Time.

b. Location.—Any of these types may be designed for use in the nose or the tail of the bomb.

97. Care and precautions in handling.—Bombs and components will be handled as specified in chapter 3. In addition, the following will be observed:

a. Primers and detonators will be handled with the greatest care at all times. Special care will be taken to see that primer-detonator and fuze cavities are free from all foreign material prior to assembling these components to a bomb.

b. Prior to assembling and handling service bombs, personnel should be trained in such drill and practice with drill bombs and inert components as will insure safe and proper assembly.

c. Due care will be exercised to see that the section of arming wire protruding beyond the fuze is smooth and straight, as kinks or burs may cause a hung bomb.

98. Packing and marking.—*a. Packing.*—(1) All bombs are shipped and stored unfuzed. The nose and tail fuze openings are closed with shipping plugs which will not be removed except when the bomb is being inspected or the complete round is being assembled.

(2) In general, bombs weighing 100 pounds or less are shipped as an unassembled complete round in one package. Bombs weighing 300 pounds or more are shipped in two packages; one, the loaded bomb body with shipping bands, the other containing the fin assembly and other components required for the round.

b. Marking.—(1) Wherever appropriate, the color scheme used for painting the bombs described in paragraphs 8 and 89 is used on the packing boxes or crates. All information for identification and directions for shipping are marked on containers for bombs and components and on the bomb bodies when no container is used.

(2) A list of all separate components required for the complete round is stenciled on the shipping container in which these components are ordinarily packed. It is usual, however, to store these components separately and, when such is the case, the word WITHOUT is stenciled above the list of components on the shipping container. When the separate components are packed with their respective bomb or fin assembly for shipment, the word WITHOUT is painted out and a card, listing the components as packed, is inserted in the accessory tray, tube, or box.

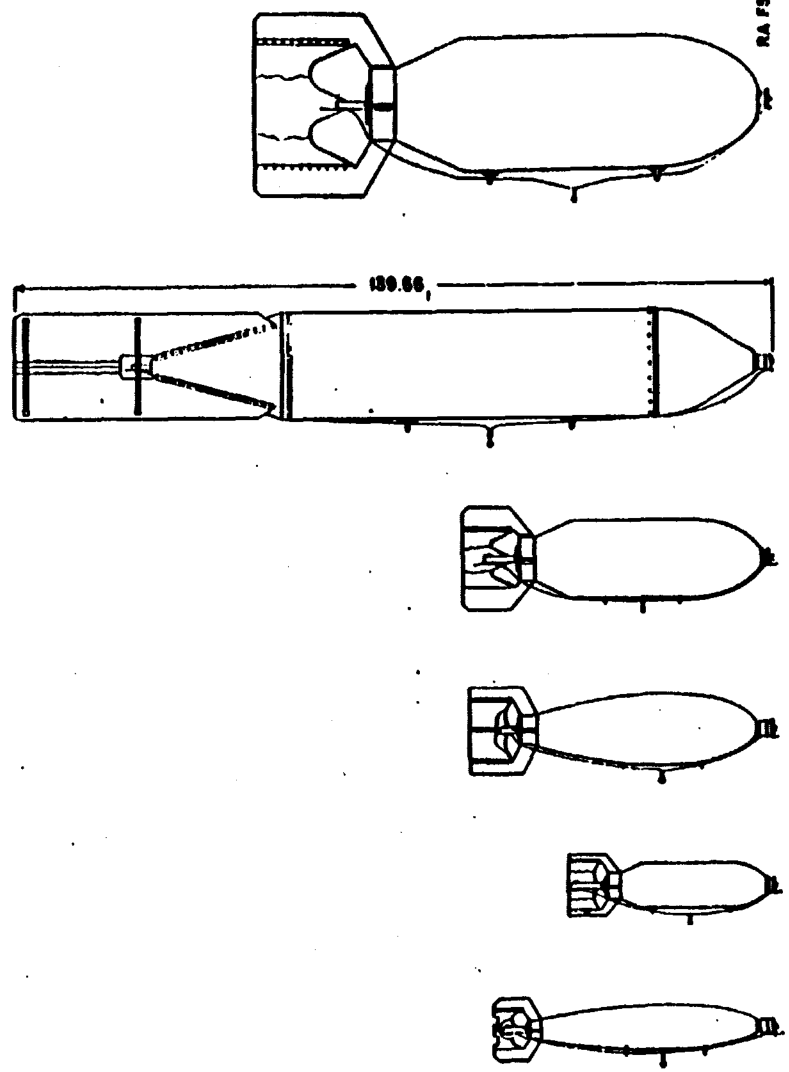


FIGURE 43.—Types of demolition bombs.

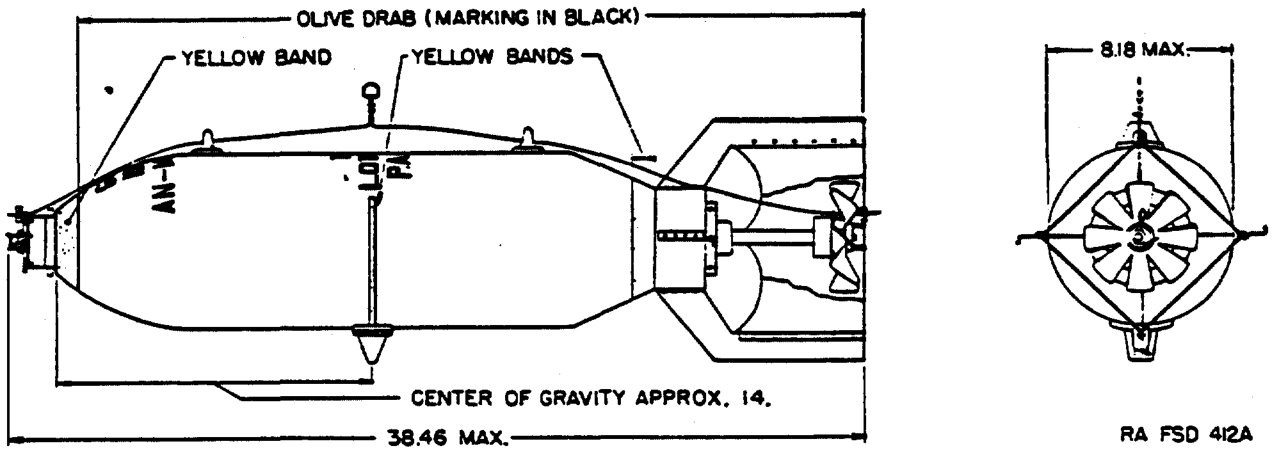


FIGURE 44.—Bomb, demolition, 100-pound, complete round.

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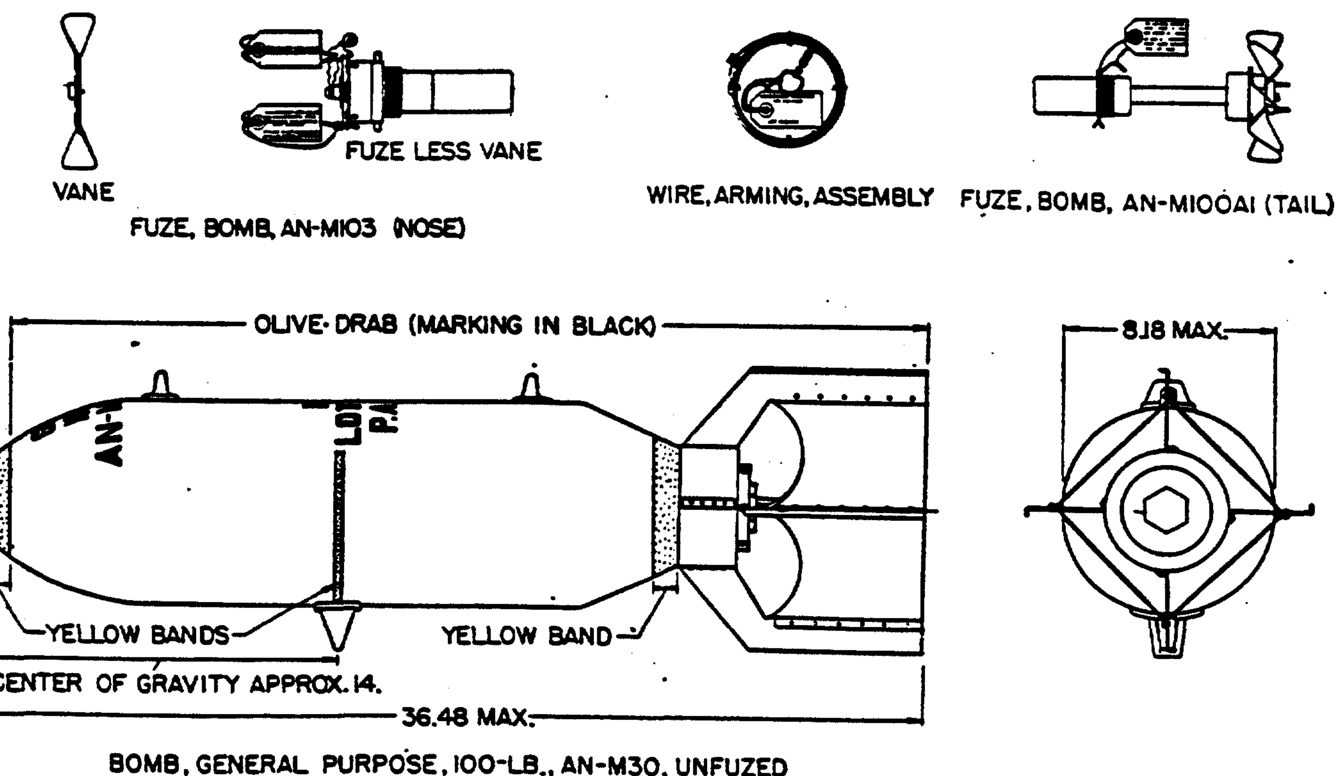


FIGURE 45.—Bomb, demolition, 100-pound, components, complete round.

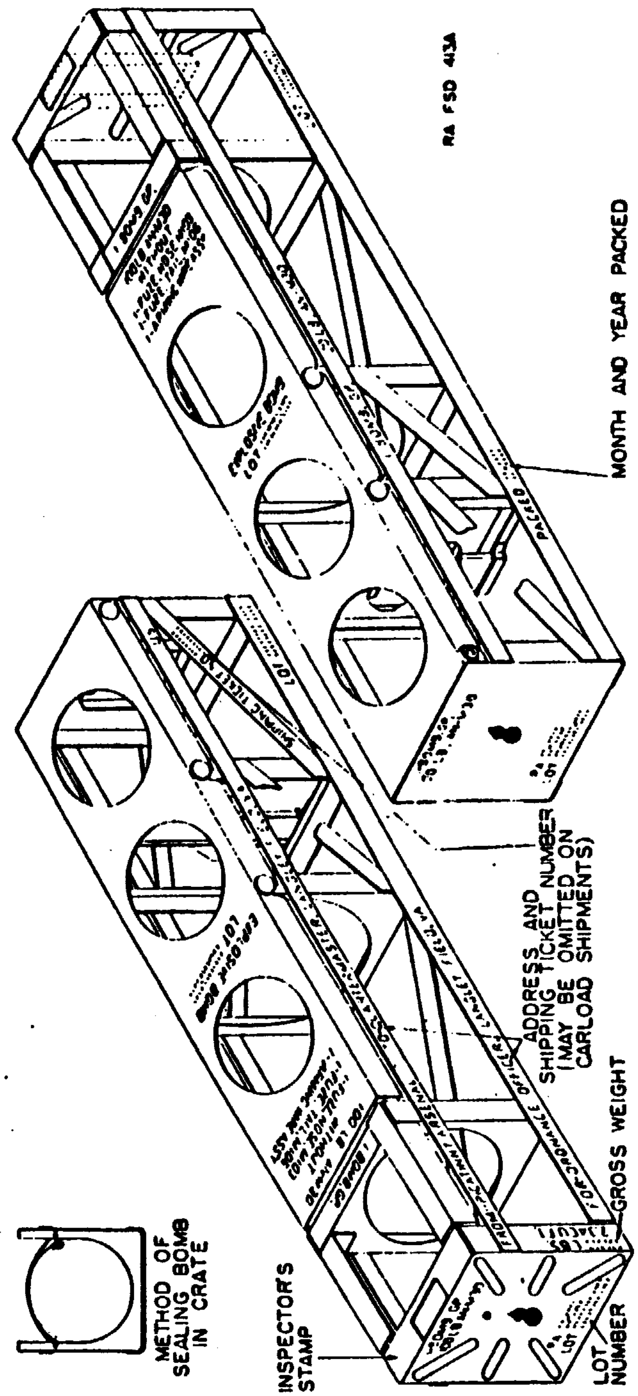


FIGURE 46.—Bomb, demolition, packing and marking of crate.

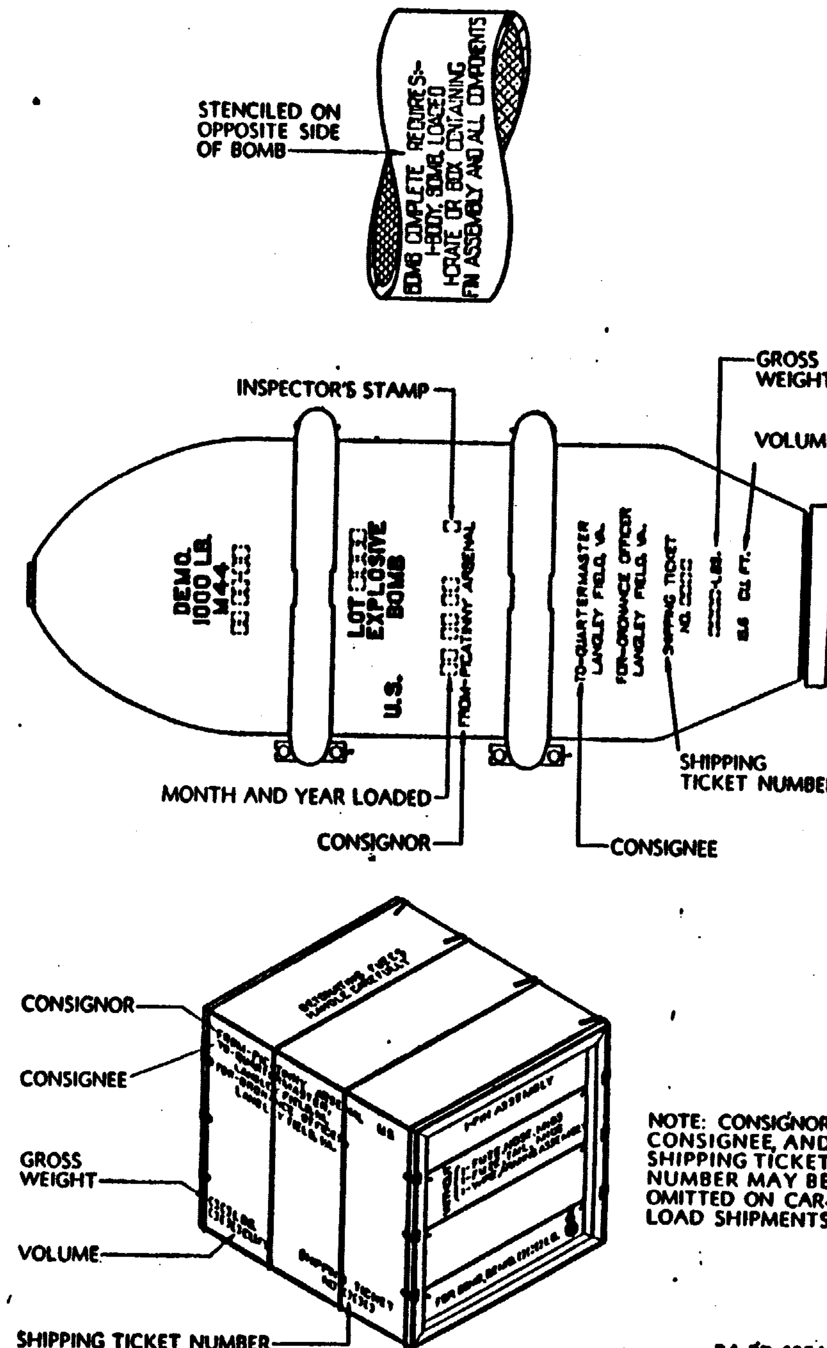
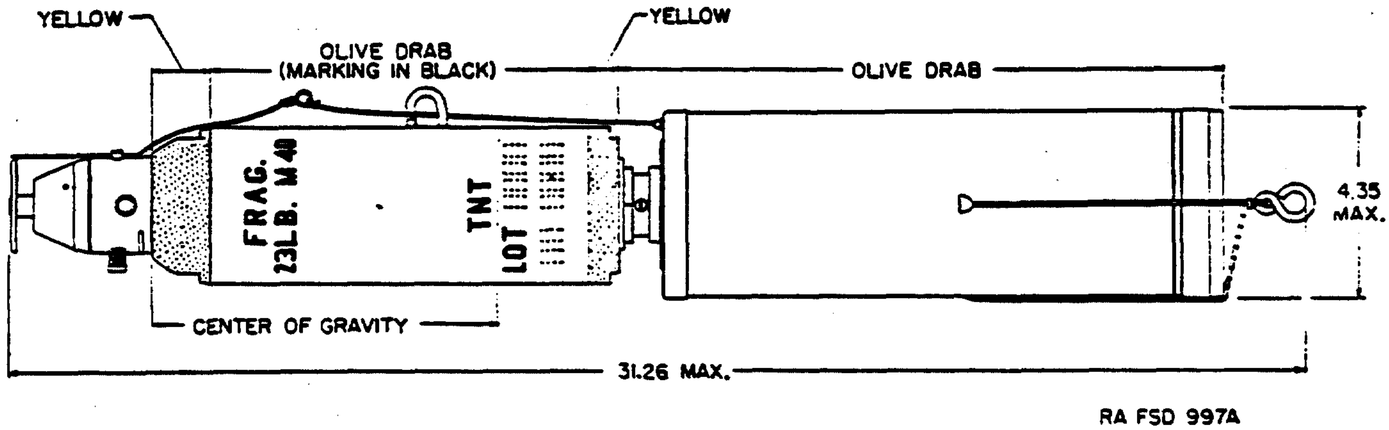
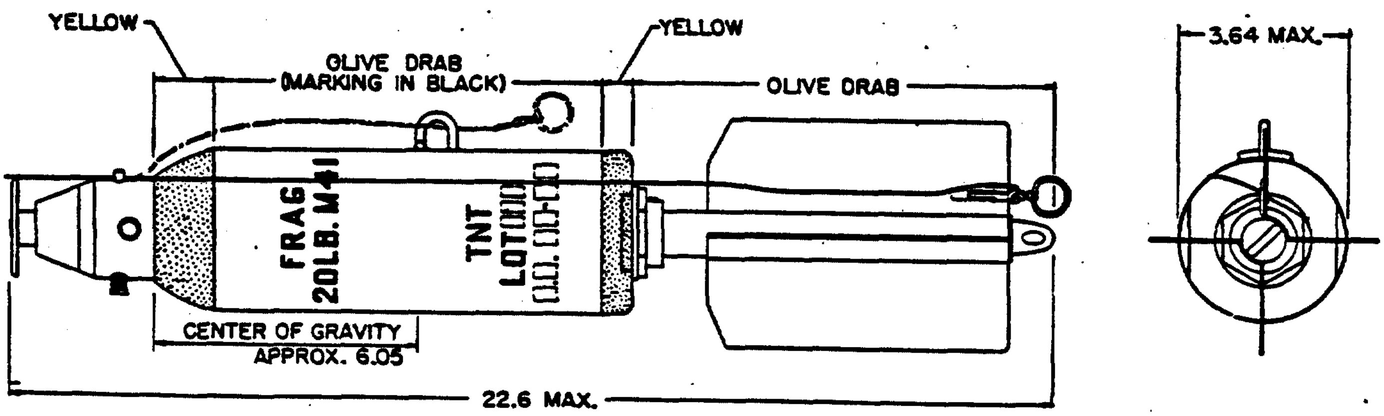


FIGURE 47.—Bomb, demolition, 1,000-pound (as shipped).



① Bomb, fragmentation, 23-pound.

NOTE:
FOR VERTICAL SUSPENSION, ASSEMBLE ONE FIN BLADE IN LINE WITH SUSPENSION LUG, ON BOMB BODY AS SHOWN.
FOR HORIZONTAL SUSPENSION, ASSEMBLE FIN BLADES AT 45° TO SUSPENSION LUG ON BOMB BODY.



② Bomb, fragmentation, 20-pound.

Figure 48.

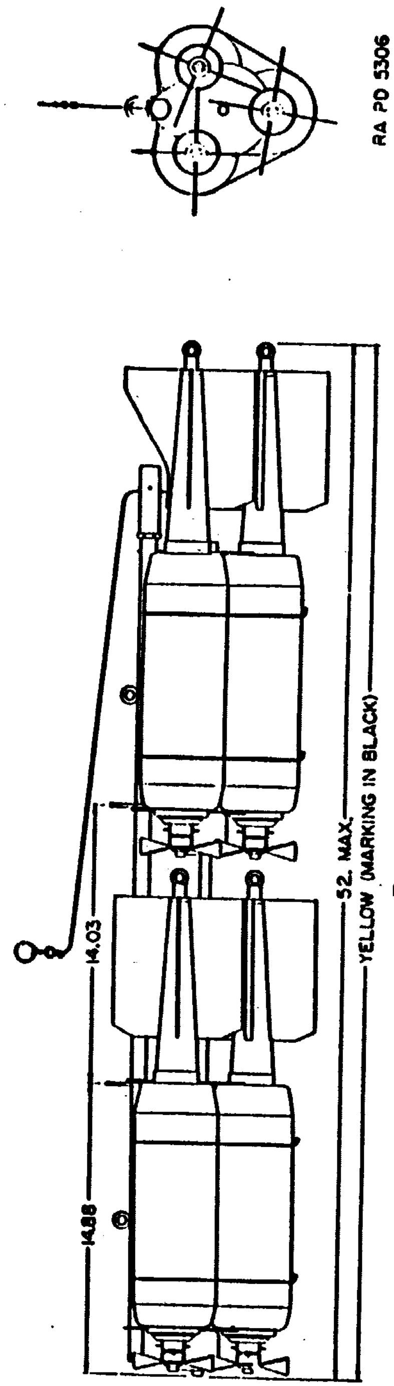


Figure 49.—Fragmentation bomb cluster.

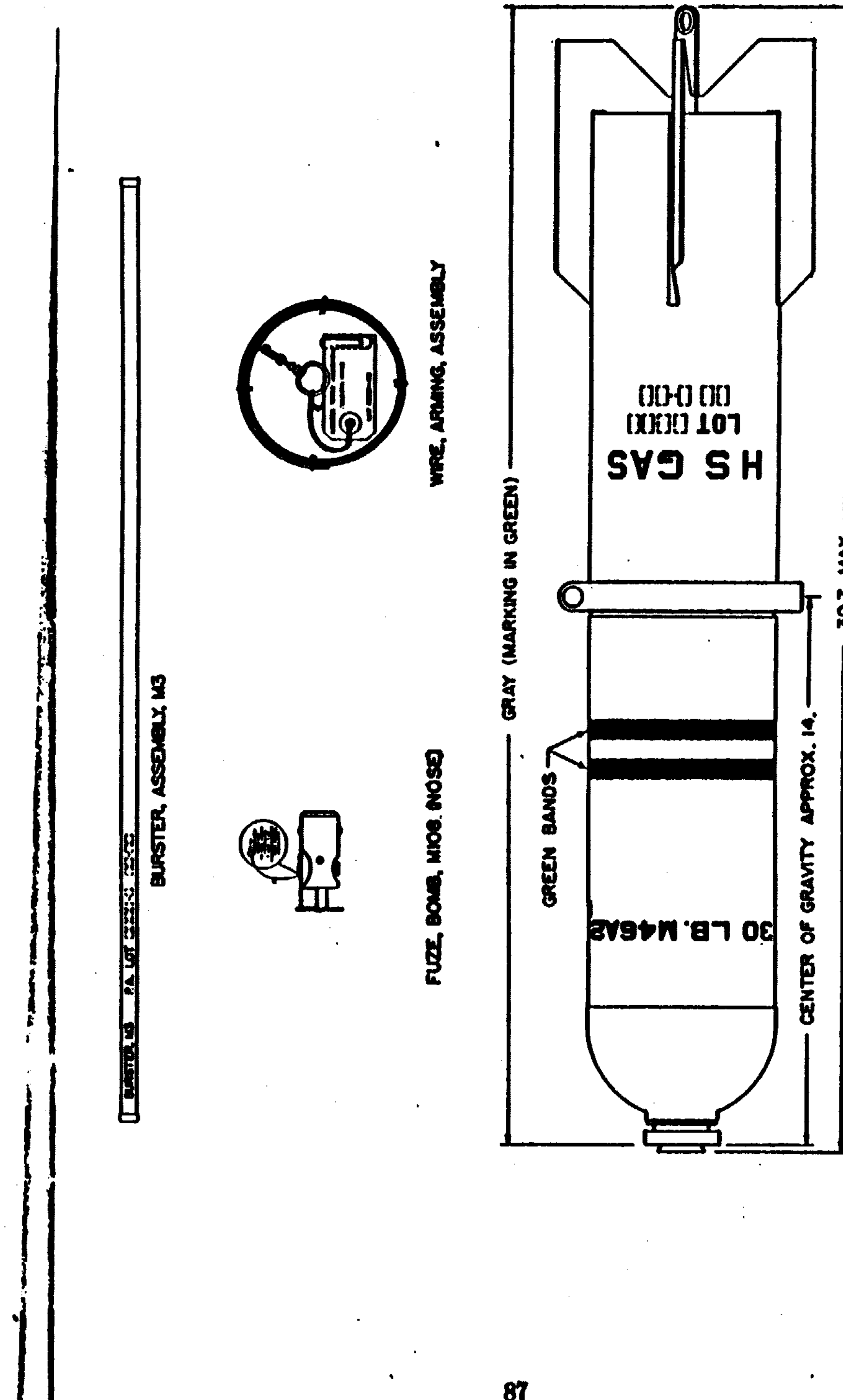


Figure 50.—Bomb, gas, persistent, HS, 30-pound.

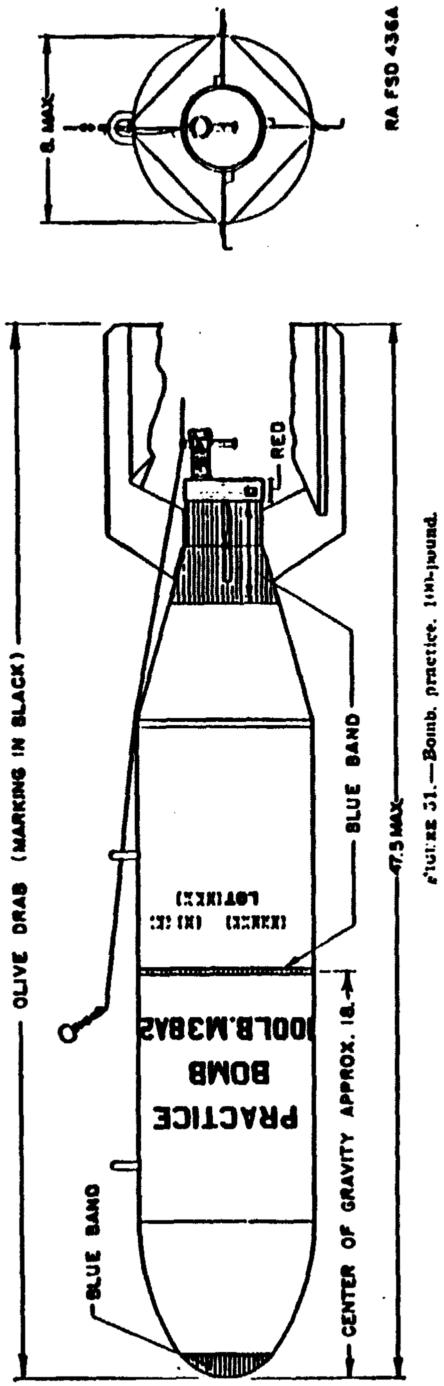


FIGURE 51.—Bomb, practice, 100-pound.

SECTION VII

PYROTECHNICS

Paragraph

99. General.—Military pyrotechnics (fig. 52) are designed to produce a brilliant light for purposes of illumination, or colored lights or smokes for signaling. Some types are projected from, or used on, the ground; others are released or projected from airplanes.

100. Classification.—*a.* According to use, pyrotechnics may be classified as—

Ground—for use from the ground.
Aircraft—for use from aircraft.

b. A further grouping according to purpose is—

Signals or lights—for signaling.
Flares or photoflash bombs—for illumination.

c. Any of the above types, when provided with a parachute, is known as a parachute type.

101. Pyrotechnic compositions.—*a.* A pyrotechnic composition is a physical mixture of chemical elements and compounds which produces illumination ranging from the "dark fire" used as elements of blinker signals to the brilliant flash used in night photography.

b. Pyrotechnics generally function by means of an igniter train analogous to the explosive train. It is initiated by a primer mixture, intensified by a "first-fire compound" which properly ignites the luminous candle.

c. Standard pyrotechnic composition, in general, consists of chlorates to provide oxygen for burning; aluminum or magnesium for fuel; barium, copper, and strontium salts for color; and a binding and waterproofing agent such as asphalt or paraffin.

102. Visibility of pyrotechnic signals.—While the distance at which pyrotechnic signals are visible and distinguishable varies with candlepower, color, and weather conditions, the following data may serve as a basis for use. Probable distances at which signals are distinguishable under average weather conditions:

Type of signal	Approximate candlepower	Distinguishability (miles)	
		Day	Night
White star parachute	35,000	2.5	7 to 10
Red star cluster	18,000	0.6	2
Red star parachute	10,000		
Red chain parachute	1,500		

NOTE.—Signals may be visible, but not distinguishable, at greater distances. The visibility of colors in clear air is approximately as follows: green, 1; white, 1.1; amber, 1.4; red, 2.8.

103. Flares.—*a. General.*—Flares (fig. 52) are used for illumination of terrain during night operations involving reconnaissance, bombardment, photography, and landing.

b. Reconnaissance flare.—The flare, aircraft, parachute, M9, shown in figure 55, was developed to satisfy the requirement for a small parachute flare for reconnaissance work. It is fired from the pistol, pyrotechnic, M2, and functions approximately 2½ seconds after firing. The candle burns for one minute, producing a light of 60,000 candlepower.

c. Night bombing flares.—(1) The flare, aircraft, parachute, M24, shown in figure 58, is used for night bombing. It is a parachute type provided with shade to protect the bombardier from the glare of the burning candle. The candle burns for 3½ minutes, producing a yellowish light of 800,000 candlepower. The flare is designed for installation in standard horizontal bomb racks, and may be released either "armed" or "safe." If released "safe," the flare may function on impact. When released "armed," the flare becomes fully ignited 5 seconds after release.

(2) The flare, aircraft, parachute, M26, shown in figure 56, is stabilized with fins and fitted with a mechanical time fuze adjustable for settings from 15 to 90 seconds. It is designed to function at a predetermined time after release, depending upon the setting of the time fuze. Functioning of the fuze projects the candle, shade, and parachute from the case. The candle ignites when the parachute opens, and burns for 3½ minutes, producing approximately 800,000 candlepower. It contains an asbestos shade which supports the flare and shields the bombardier from the glare. It is designed for night bombardment and may be installed only in a horizontal rack in the airplane. It may be released either "armed" or "safe"; if released "safe," the flare may function on impact.

d. Emergency landing flare.—The flare, aircraft, parachute, M8A1, shown in figure 53, is intended for use in emergency landing. The flare furnishes a yellowish-white light of approximately 350,000 candlepower, and burns for approximately 3 minutes. It is designed for installation in either a vertical or horizontal rack in the airplane, and may be released either "armed" or "safe." If released "safe," the flare may function on impact. When released armed, the flare becomes fully ignited approximately 5 seconds after release.

e. Airport flare.—The flare, airport, M13, illustrated in figure 54, is designed for lighting airfields in emergencies, should the floodlighting system fail. It is ignited by means of a quick pull on the lanyard. The flare produces illumination in excess of 40,000 candlepower for 3 minutes.

104. Photoflash bombs.—The bomb, photoflash, M23, illustrated in figure 57, is designed to produce a brilliant light of short duration for night photography. It is equipped for installation in aircraft in standard horizontal or vertical flare racks. It functions approximately 15 seconds after release to produce a flash of 150,000,000 candlepower for 0.16 second. It may be dropped armed or safe but, if dropped safe, may function on impact.

105. Aircraft signals.—*a.* Aircraft signals and the pistol from which they are fired are illustrated in figure 59. The signal is contained in a signal case with an expelling charge. The signal case in turn is contained in a "barrel" with a propelling charge. When the pistol is fired, the propelling charge, in addition to projecting the signal case ignites a fuze. After 2.5 seconds the fuze ignites the expelling charge, which in turn expels the signal and ignites the pyrotechnic composition.

b. The signals currently authorized for use are—

(1) Signal, aircraft, red star, parachute, M11.
(2) Signal, aircraft, red star cluster, M14.
(3) Signal, aircraft, white star, blinker, parachute, M15.
(4) Signal, aircraft, green star, blinker, M16.
(5) Signal, aircraft, double star, red-red, AN-M28.
(6) Signal, aircraft, double star, yellow-yellow, AN-M29.
(7) Signal, aircraft, double star, green-green, AN-M30.
(8) Signal, aircraft, double star, red-yellow, AN-M31.
(9) Signal, aircraft, double star, red-green, AN-M32.
(10) Signal, aircraft, double star, green-yellow, AN-M33.
(11) Signal, aircraft, single star, red, AN-M34.
(12) Signal, aircraft, single star, green, AN-M36.
(13) Signal, aircraft, single star, yellow, AN-M35.
(14) Signal, aircraft, white star, parachute, M10 (limited standard).

c. Aircraft signals are identified by the color and marking on the identification top (outer wad).

106. Drift signals.—*a.* Drift signals are used as an aid in navigation for aircraft flying over water. They are small bomb-shaped signals with stabilizing fins. They are dropped by hand over the side of the airplane.

b. Signal, drift, M25 (fig. 62) is designed to function 8 seconds after impact with water. While floating, it emits a flame accompanied by a column of smoke. It is used for both day and night navigation.

c. Signal, drift, day, AN-Mk. 1, is a light paper shell filled with a metallic powder. It bursts upon impact with water and leaves a slick on the surface.

d. Signal, drift, night, AN-Mk. 4, functions after impact with water. While it floats, it burns out of the tail, emitting flame and some smoke.

107. Ground signals.—*a.* Ground signals are designed to be fired from the projector, pyrotechnic, M1A1, M3, or M4. The signals are equipped with tails and fin assemblies to provide stability in flight. They are fired from the projector, tail upward. They reverse at approximately 100 feet and rise to an altitude of approximately 600 feet before the signal is ignited and ejected from the case. The projector, pyrotechnic, M1A1, which is fired by use of a lanyard, is for use with the high burst ranging signal. The M3 and M4 projectors are fired by striking the projector smartly on the ground. This drives the signal primer against a fixed firing pin.

b. The signals currently authorized are as follows:

(1) Signal, ground, amber star cluster, M22.
(2) Signal, ground, amber star, parachute, M21.
(3) Signal, ground, green star cluster, M20.
(4) Signal, ground, green star, parachute, M19.
(5) Signal, ground, white star cluster, M18.
(6) Signal, ground, white star, parachute, M17.
(7) Signal, ground, high burst ranging, M27.

c. Limited standard signals are—

(1) Signal, ground, red chain, parachute, M7.
(2) Signal, ground, red star cluster, M6.
(3) Signal, ground, white star, parachute, M5.

d. Standard ground signals are identified by the color and marking on the fin. Limited standard ground signals are identified by the color and marking on the identification top (outer wad).

108. Very signal lights.—These are the plain cartridge type of ground signal fired from a pistol (fig. 61). They contain a primer, expelling charge, quick match, and illuminant charge. The color of the signal, red, white, or green, is indicated by the form and color of

the top wad of the cartridge. The signals burn for approximately 5 seconds.

109. Care and precautions in handling.—*a. Storage.*—Pyrotechnics should be protected against moisture. Containers which show signs of dampness or moisture will be carefully examined, and if there is any evidence of moisture on the pyrotechnics they will be destroyed. Pyrotechnics should be handled with care and protected against shock; the boxes should not be dropped or thrown. They should not be stored with other kinds of ammunition. Photoflash bombs which have become damaged in handling or storage should be destroyed in accordance with the provisions of chapter 4. They will not be disassembled under any circumstances.

b. Flares.—For information concerning the serviceable life of flares and disposition of overage flares, see OFSB 8-9.

c. Toxicity.—Pyrotechnic material is poisonous to men and animals if taken internally.

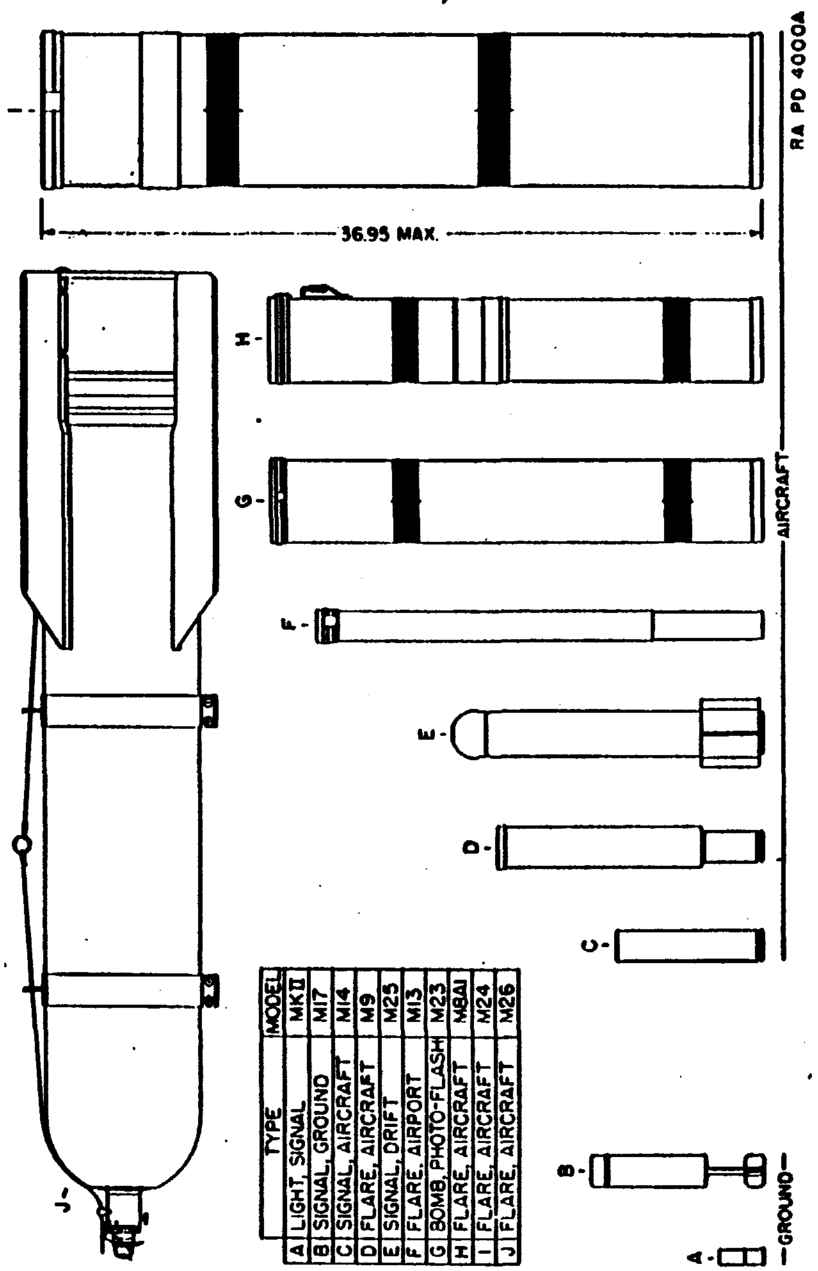
d. Recoil.—Both hands should be used to hold the pistol when discharging the flare, aircraft, parachute, M9, because of the powerful recoil.

e. Fires.—The incendiary effect of pyrotechnic material should be kept in mind in using such material in the vicinity of dry brush and grass.

f. Duds.—During maneuvers over terrain other than military reservations the location of dud flares and photoflash bombs will be observed. The duds will be sought out and destroyed as soon as possible.

110. Packing and marking.—*a. Packing.*—Pyrotechnics are packed in metal-lined or unlined, nailed or wire-bound wooden boxes. Those in unlined boxes are packed in inner containers consisting of sealed corrugated-board cartons, cylindrical fiber containers, or metal containers. The cartons are dipped in paraffin to protect the contents from moisture. The containers are labeled or marked to show the type or kind, lot number, quantity, and limiting date for use, if any.

b. Painting and marking.—Pyrotechnics are marked in such a way as to provide positive identification for all purposes. Each item is marked to show the type or kind, lot number, and limiting date for use, if any.



	TYPE	MODEL
A	LIGHT, SIGNAL	MK II
B	SIGNAL, GROUND	M17
C	SIGNAL, AIRCRAFT	M14
D	FLARE, AIRCRAFT	M9
E	SIGNAL, DRIFT	M25
F	FLARE, AIRPORT	M13
G	BOMB, PHOTO-FLASH	M23
H	FLARE, AIRCRAFT	M8A1
I	FLARE, AIRCRAFT	M24
J	FLARE, AIRCRAFT	M26

FIGURE 52.—Types of pyrotechnics.

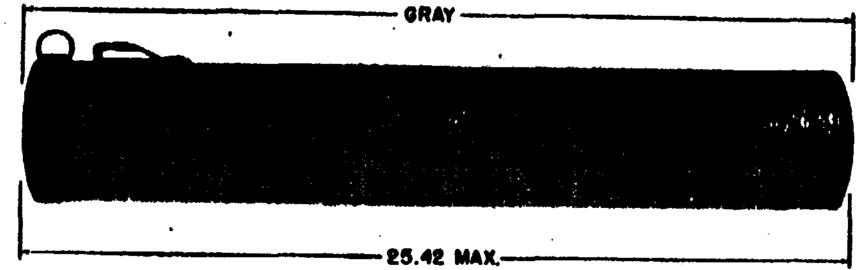


FIGURE 53.—Flare, aircraft, parachute, M8A1.

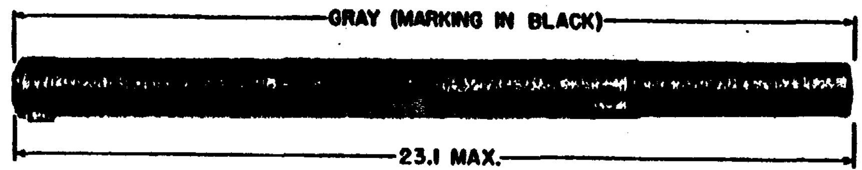


FIGURE 54.—Flare, airport, M13.

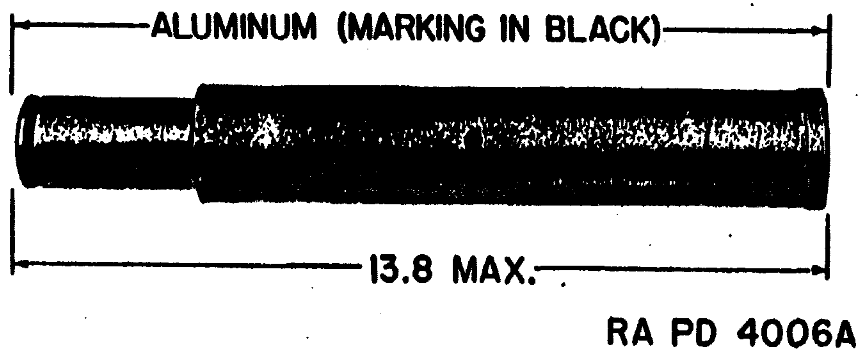


FIGURE 55.—Flare, aircraft, parachute, M9.

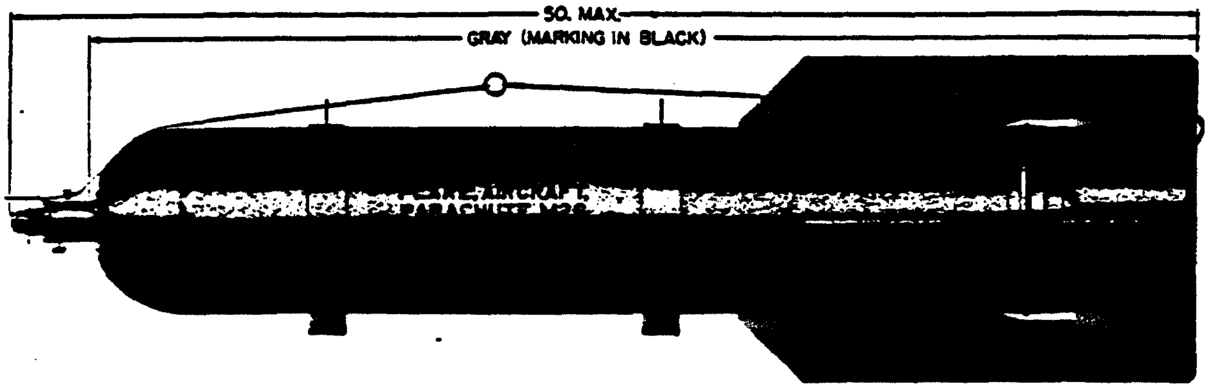


FIGURE 56.—Flare, aircraft, parachute, M26.

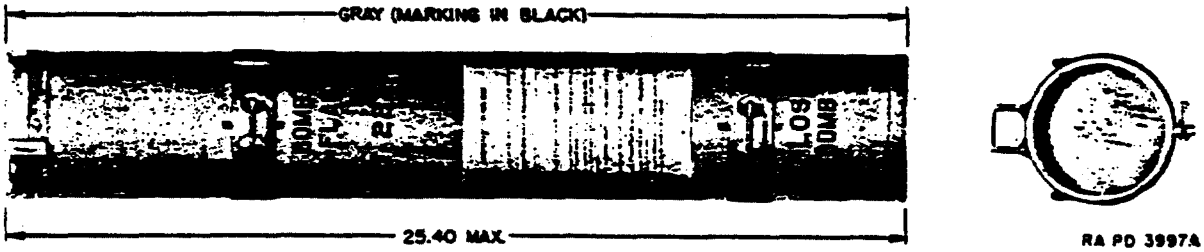


FIGURE 57.—Bomb, photoflash, M23A1.

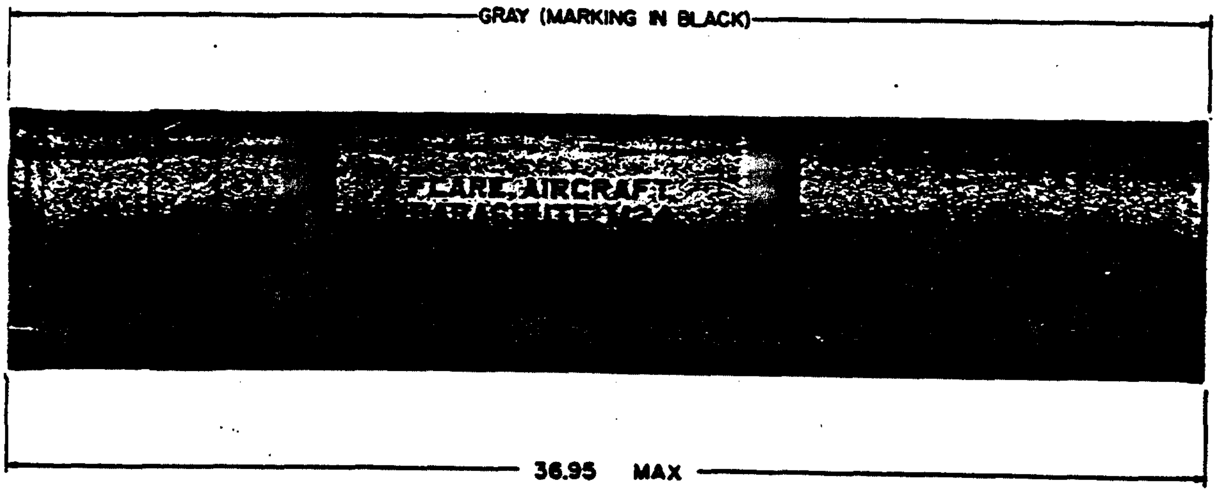


FIGURE 58.—Flare, aircraft, parachute, M24.

IDENTIFICATION TOP FOR:	COLOR	IDENTIFICATION TOP FOR:	COLOR
A—SIGNAL, AIRCRAFT, PARACHUTE, RED STAR, M11	RED	F—SIGNAL, AIRCRAFT, DOUBLE-STAR, AN-M29	YELLOW-YELLOW
B—SIGNAL, AIRCRAFT, SINGLE-STAR, AN-M34	RED	G—SIGNAL, AIRCRAFT, DOUBLE-STAR, AN-M30	GREEN-GREEN
C—SIGNAL, AIRCRAFT, SINGLE-STAR, AN-M35	YELLOW	H—SIGNAL, AIRCRAFT, DOUBLE-STAR, AN-M31	RED-YELLOW
D—SIGNAL, AIRCRAFT, SINGLE-STAR, AN-M36	GREEN	I—SIGNAL, AIRCRAFT, DOUBLE-STAR, AN-M32	RED-GREEN
E—SIGNAL, AIRCRAFT, DOUBLE-STAR, AN-M28	RED-RED	J—SIGNAL, AIRCRAFT, DOUBLE-STAR, AN-M33	GREEN-YELLOW

X—ALUMINUM (MARKING IN BLACK)

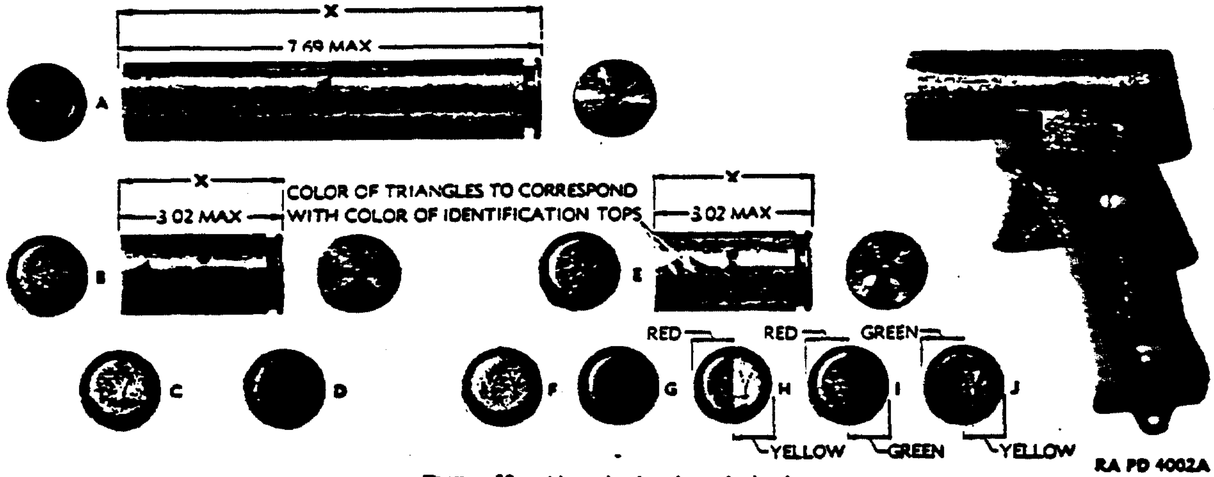


FIGURE 59.—Aircraft signals and pistol.

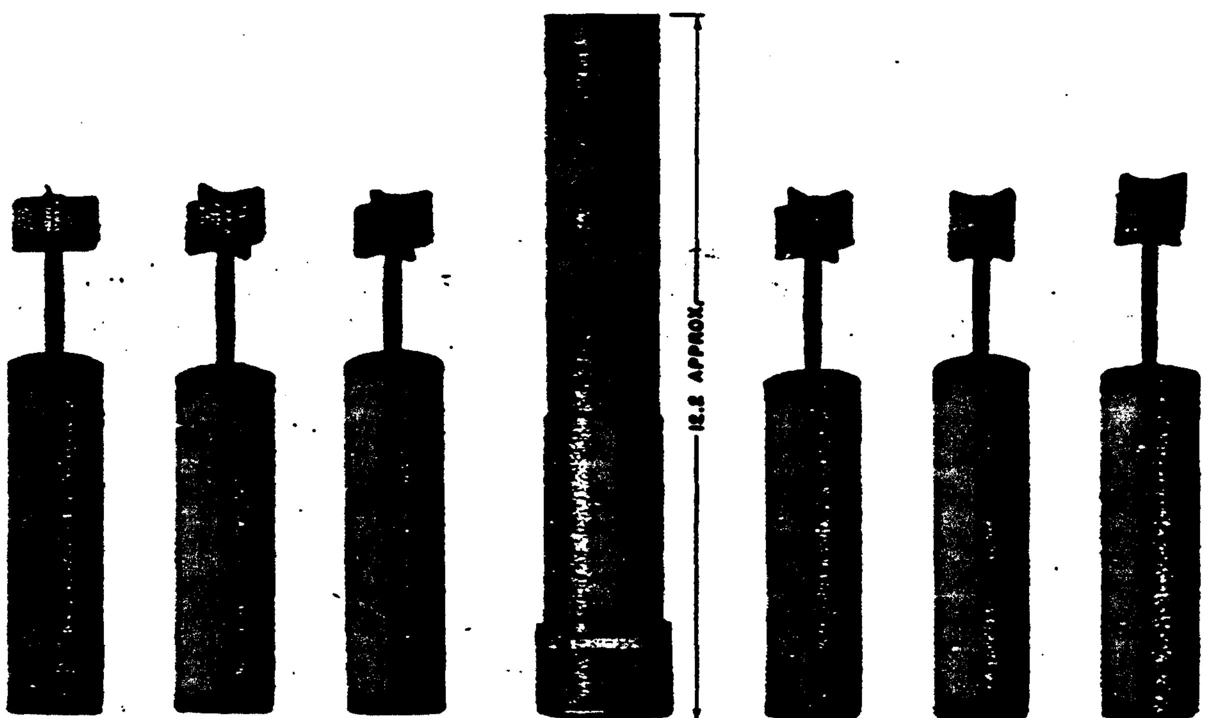


FIGURE 60.—Ground signals and projector.

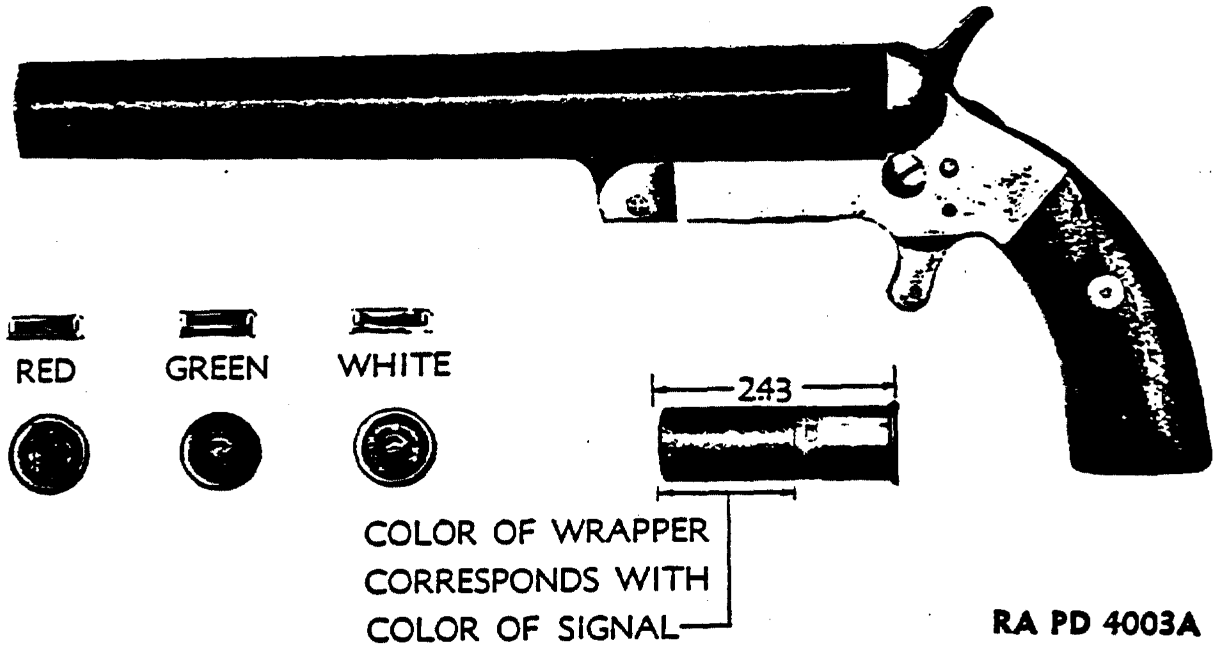


FIGURE 61.—Very signals and pistol.

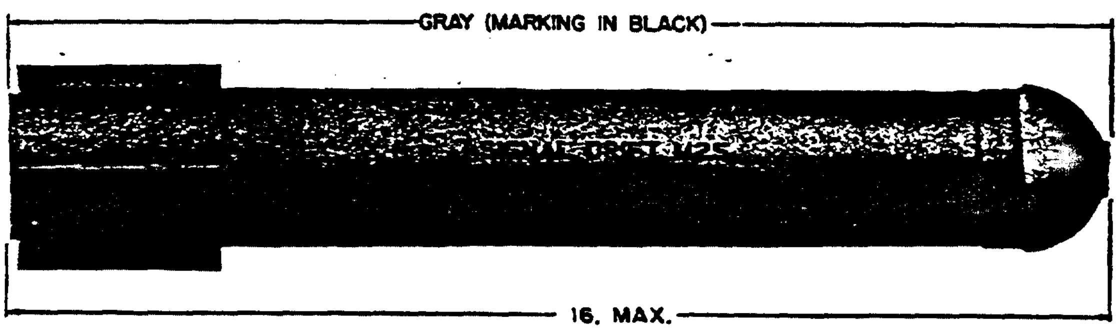


FIGURE 62.—Signal, drift, M25.

CHAPTER 3

CARE, HANDLING, AND PRESERVATION

SECTION I

GENERAL SAFETY PRECAUTIONS

111. General precautions.—*a. General.*—A study of accidents which have occurred in the handling, shipping, and storage of explosives and ammunition shows that, in practically every instance where the cause could be determined, the accident has been due to circumstances which may be classed as avoidable. Therefore, the following general safety precautions will be strictly enforced.

b. For personnel.—(1) Ammunition should be handled under the direct supervision of an officer or other competent person who understands thoroughly the hazards and risks involved. Persons handling ammunition should be impressed with the fact that their safety as well as that of others depends upon the intelligence and care exercised by themselves and by their fellow workers.

(2) Personnel handling ammunition should not be permitted to tamper with or disassemble any components. Serious accidents may result.

(3) Persons handling ammunition should clean all mud and grit from their shoes before entering the magazine, car, or boat in which there are explosives or ammunition.

c. Safety shoes.—Safety shoes should be worn whenever explosive dust is present, such as at black powder or high explosive loading operations. Safety shoes are shoes without exposed metal plates or nails and without insulating rubber soles.

d. Handling ammunition.—(1) Explosives and ammunition should be handled carefully. Bale hooks will not be used. Containers will not be tumbled, dragged, thrown, or dropped on each other or on the floor.

(2) All tools used when repairing, opening, or closing containers filled with hazardous explosives should be of nonferrous or nonsparking materials.

(3) Explosives and ammunition should not be exposed to moisture or dampness or to the direct rays of the sun for any long period. If it is necessary to leave boxes temporarily outside of magazines or cars, they should be covered with a tarpaulin which is so placed that air can circulate freely through the pile.

(4) Ammunition will not be reconditioned, renovated, or salvaged within the magazine area unless the sites, buildings, or cars in which work is being done are devoted exclusively to such work and are specifically approved by the commanding officer.

e. Containers.—If explosives spill or sift from a leaky container, all work will be stopped until the explosives have been swept up and removed and any remaining particles or dust have been neutralized with water.

f. Fire precautions.—(1) Matches or other flame-producing devices will not be permitted in any magazine or magazine area except by written permission from the commanding officer. When necessary, permits will be granted to carry safety matches. They will be carried in a closed metal receptacle.

(2) Smoking will be absolutely prohibited in any magazine or magazine area, or around cars, wagons, motor trucks, or boats in which there are explosives or ammunition.

(3) No portable lights other than approved electric lanterns and flashlights will be used in magazines or around explosives and ammunition in cars, wagons, motor trucks, or boats. Electric lanterns and flashlights approved by the Bureau of Mines or by Underwriters Laboratory for Class 1 Group D locations may be used in lieu of such items approved by the Chief of Ordnance.

(4) All electric light and power lines where authorized within buildings containing ammunition and explosives or explosive vapors will be installed in accordance with drawings and specifications approved by the Chief of Ordnance.

112. Guard protection.—*a.* Magazines and magazine areas in which there are explosives and ammunition should be adequately guarded at all times. Magazine areas should be protected by nonclimbable fences and all entrances should be securely locked unless guards are stationed at them. Special precautions should be taken to guard areas which are not protected by a suitable fence.

b. Guards and others in charge of explosives and ammunition will be thoroughly instructed as to the hazards due to fire and explosion and the safety precautions to be taken.

c. Guards should be instructed to make a prompt report of the following:

(1) Any unusual occurrence in or near a magazine area.

(2) Grass or forest fires in areas adjacent to the magazine area.

(3) Conditions which are or may become fire hazards, such as long grass, undergrowth, and other vegetation in the vicinity of magazines.

(4) Dangerous practices of personnel working in magazines or explosive areas, such as smoking, unauthorized use of fire equipment, and tampering with ammunition or electrical equipment.

(5) Unlocked magazine doors and shutters, defective telephone and electric wires, and openings in fences.

d. Hunters in the area adjacent to magazines who are discovered using firearms in a manner that may endanger military stores will be warned and, if necessary, reported.

e. Airplanes flying over an explosives area at an altitude of less than 500 feet will be observed for identification and reported.

f. Guards protecting explosives or ammunition will be instructed regarding the danger in firing in the direction of a magazine.

g. Guards will be instructed that their most important duty is to protect explosives and ammunition against fire. Alarms will be given with the greatest possible speed so as to start action instantly, as serious fires and explosions have been avoided by prompt action of fire-fighting forces. After giving the alarm, guards will exert every effort to hold the fire under control until the fire-fighting forces arrive, except that should a fire occur in a closed magazine, they will not attempt to enter the magazine.

113. Fire protection.—*a. General.*—Many of the fires involving explosives and ammunition are preventable. It is the duty of all concerned in the handling of explosives and ammunition to study the causes of fires and thoroughly inform themselves of the safety precautions that must be taken to prevent them.

b. Causes of fires.—Fires in magazines and magazine areas in which explosives and ammunition are stored may be due to several causes, of which the following are the most common:

(1) Dry grass, leaves, and underbrush ignited by sparks from locomotives, by smoking, or the careless use of matches and camp fires.

(2) Deteriorated explosives and ammunition. Explosives and ammunition deteriorate in storage. Normally this deterioration occurs at such a slow rate that most explosives and ammunition remain serviceable for many years. However, under unfavorable storage conditions, explosives and ammunition give off heat so fast that it cannot be dissipated, and it causes the explosive or ammunition to burst into flame. In certain cases where the explosive or ammunition is confined, an explosion or detonation may result.

(3) Repacking, renovation, and salvage operations not properly supervised and conducted in accordance with recognized safety standards. The most common sources of trouble are excessive quantities of powder and loose explosives, accumulation of waste paper, broken boxes, etc., and failure to provide the proper barricades and firebreaks necessary to prevent the spread of fire from one operation to another.

(4) Careless or untrained employees or other persons who violate regulations by smoking, building fires, or striking matches in forbidden areas and buildings, or who tamper with explosives or ammunition, particularly grenades or fuzes.

(5) Failure to understand and carefully observe the safety precautions prescribed in this manual for destroying explosives and ammunition. The most frequent source of trouble is flying fragments which cause grass fires or explode piles of explosives and ammunition awaiting destruction.

(6) Sparks that may be caused by striking iron or steel nails or metal containers with iron or steel tools, or by nails in shoes striking flint, pebbles, sand grains, or nails in the floor. Such sparks, small as they are, have often caused disastrous explosions of black powder or of the dust of other explosives which ignite easily, and are the basis of the requirements in certain places in this manual for tools of brass, copper, or other nonsparking materials; for cleaning mud and dirt from shoes before entering magazines; and for wearing safety shoes (shoes without exposed metal nails or plates).

(7) Static electricity. A considerable charge of electricity may accumulate on smokeless powder and upon the body of an operator during handling operations. When a person so charged approaches powder or explosives, a spark may jump between him and the powder or explosives and ignite them. Personnel engaged in handling operations should go occasionally to the door and touch a suitable ground to remove a possible charge.

(8) Failure to provide proper safeguards for heating appliances, such as torches and furnaces, used in making repairs to magazine roofs and magazines.

(9) Lightning strikes buildings, trees, or other objects in or near explosive areas.

(10) Electric transmission lines blown down or in contact with inflammable materials.

(11) Lack of a proper muffler, or the use of a muffler cut-out, on motor vehicles.

c. Special fire-prevention rules.—Fire prevention is of the utmost importance because of the difficulties encountered in controlling fires involving explosives and ammunition. The special precautions that should be taken to prevent fires are set forth below.

(1) The duties of guards, firemen, military personnel, and others will be so arranged that an adequate fire-fighting force will be available at all times.

(2) Fire drills and inspections will be carefully conducted to insure that fire-fighting forces understand their duties and that fire-fighting equipment functions dependably under actual working conditions. Hose not tested to working pressures frequently bursts when most needed.

(3) To combat grass or forest fires in or near the magazine areas, there will be maintained at suitable locations an adequate supply of gunny sacks, brooms, rakes, hoes, or other similar equipment. This equipment should be regularly inspected and protected against theft or unauthorized use.

(4) When explosives and ammunition are being handled or work is being done in the immediate vicinity of such stores, there should be present ready for immediate use two chemical or other type hand fire extinguishers. It is not required that these be permanently located in a magazine, although this should be done if practicable, but it is required that they be present when employees need them. Many serious fires have been avoided by the prompt use of hand fire extinguishers.

(5) Vegetation in the form of grass, undergrowth, weeds, etc., which is or may become a fire hazard, will be controlled by the use of chemical weed killer or by mowing, plowing, cutting, or, in calm weather and under adequate safeguard, by burning. Burning should not be permitted within the 50-foot space specified in (b) below, and brush, grass, wood, etc., in piles will not be burned within 200 feet of a magazine.

(6) A firebreak at least 50 feet wide and as free as practicable from inflammable material will be maintained around each above-ground magazine. The earth adjacent to and extending over igloo magazines will not be cleared of vegetation other than dry debris. Firebreaks around the entire magazine area and at other places within the magazine area, such as along railroad tracks, should be maintained wherever possible.

(7) All locomotives used in or near a magazine will be so equipped

or of such a type that the possibility of their setting or communicating a fire is reduced to a minimum.

(8) Water lines should be divided into sections by cut-off valves, and water mains should not be located under railroads or roads used for conveying large quantities of explosives and ammunition, as a detonation of a large quantity of explosives over a water main may cause the loss of all the water in the system. Railroad cars or trucks loaded with explosives or ammunition will not remain over water lines longer than is necessary to pass from one side to the other.

(9) The use of highly inflammable liquids, especially gasoline, for cleaning purposes should be eliminated. Solvent, dry-cleaning (Federal Specifications P-S-661, SNL Kl-2a), will be used in all cases in which solvents of this nature are required. It should be remembered, however, that dry-cleaning solvent is also inflammable, differing from gasoline in having a higher flash point. In handling dry-cleaning solvent, AR 850-20, "Precautions in Handling Gasoline," should be observed in all cases. This regulation should not be interpreted to forbid the use of carbon tetrachloride, trisodium phosphate, and other noninflammable cleaning agents. Due to the toxicity of vapors from cleaning agents adequate ventilation must be provided.

(10) Parking of automobiles in the immediate vicinity of ammunition or explosives areas should be so controlled as to minimize fire hazards. Fires of either accidental or incendiary origin may, by causing fuel-tank explosions, result in trails of burning fuel carrying the conflagration to adjacent cars or buildings.

(11) The use of metal tools, fixtures, and equipment which are not grounded should be kept to a minimum.

(12) These rules will be supplemented by such additional rules as the commanding officer deems necessary to secure adequate protection against fires at his establishment.

d. Fire-fighting facilities.—A fire involving explosives or ammunition may result so quickly in an intense conflagration or explosion that means for immediately attacking the first small blaze detected are vitally important, and reliance must often be placed upon hand equipment which can be maintained ready for immediate use. In addition to fire extinguishers, the following types of fire-fighting equipment may be used to good advantage.

(1) Water barrels and buckets placed at each magazine. If this class of fire-fighting equipment is always maintained so that it can be depended upon in case of fire, it is a valuable fire protection. However, in the summertime the barrels must be frequently refilled, and in freezing weather brine must be used. Buckets deteriorate rapidly

unless they are frequently painted or protected from the weather, and are blown about by windstorms if they are not securely fastened in place by some device which can be released at will.

(2) Sand boxes and buckets, with shovels.

e. Fire-fighting.—General instructions which will be followed in combating any fire involving explosives and ammunition are as follows:

(1) When a guard discovers smoke coming from a closed or locked magazine or other evidence that a magazine is afire, he will give the alarm as quickly as possible. He will fail in his duties if he attempts to go to the burning building and thereby possibly get trapped so that he cannot give the alarm.

(2) When a guard or watchman or other person discovers a grass fire, he will immediately give the alarm. If a box of fixed ammunition catches fire there is usually time to extinguish it, as it takes 10 minutes or more for fire to cause an explosion of fixed ammunition in boxes.

(3) Fire-fighting forces, when they arrive, will attack a grass fire vigorously and endeavor to extinguish it even when it is close to a magazine.

(4) In case a fire has actually gained headway in a magazine, fire-fighting forces should be directed not to endanger themselves in hopeless efforts to extinguish the fire, but to devote their efforts to saving the adjacent buildings.

(5) Forces engaged in fighting fires involving dangerous explosives and ammunition will always seek such cover as is available and will never unnecessarily expose themselves to the intense heat generated by burning smokeless powder, or to flying fragments from exploding ammunition. Many serious accidents have occurred to personnel running from a fire, while others much nearer to the danger have escaped injury because they were protected by cover which in some cases was very slight, such as a tree, shallow ditch, etc. Fire-fighting equipment must be halted 200 yards from a fire and all available cover used.

SECTION II
STORAGE

114. General storage precautions.—*a.* General storage regulations are contained in AR 700-10. Regulations for ordnance depots

and manufacturing plants are contained in the Ordnance Safety Manual (O. O. Form 7224). The regulations and instructions in this manual are for posts, camps, and stations.

b. Explosives and ammunition should be stored in buildings designed, designated, and isolated for the specific purpose. Explosives and ammunition should not be stored in buildings which are used for other purposes, such as basements or attics of barracks, company supply rooms, or general storehouses. When specially constructed magazines are not available, the buildings used must afford good protection against moisture and dampness and have means for adequate ventilation. They must be floored with approved material and may not be heated by open fires or stoves.

c. In these general precautions, the word "magazine" is extended to cover any closed space containing a supply of explosive material and includes such places as a railroad car, the hold of a ship, the body of a motor truck, or a temporary shelter. In matters pertaining to storage, the word "ammunition" when unqualified is restricted to mean fixed, semifixed, and separate loading shell and shrapnel.

d. Boxes, cases, and other containers of ammunition should be clean and dry before being stored. Damaged containers will be repaired or replaced before storing but the repair or change of container will not take place in or within 100 feet of a magazine containing explosives. Powder dust, particles of explosive material from broken containers, will be carefully taken up as soon as spilled. All work will be suspended until this has been done. Ammunition containers should not be opened in a magazine nor should they be stored after having been opened unless they have been closed securely. No nails or tacks will be driven into a container of explosives or ammunition. Cases should be handled with care so as not to split the metal liners. Cases should not be dragged across the floor in magazines as this practice has resulted in starting fires where there was powder dust present.

e. Loose rounds or components will not be kept in a magazine. No empty container, no excess dunnage, no tools, should be permitted to remain in a magazine. No oily rags, paint, turpentine, etc., will be left in a magazine containing ammunition or explosives.

f. Ammunition should be piled by lot number in stable piles which are so arranged that the individual containers are accessible for inspection and offer no obstacle to the free circulation of air. The tops of ammunition piles will be below the level of the eaves to avoid the heated space directly beneath the roof. The bottom layer should be raised off the floor about two inches. Dunnage should be level; if necessary, shims or wedges should be used. Stacks should not be so high that ammunition or its containers in the lower layers will be crushed or deformed. Partly filled boxes should be fastened securely, marked, and kept on the top of the pile.

g. Chemical ammunition is stored separately and is so placed that every container may be inspected for leaks and may be easily removed.

h. Doors of magazines should be closed while locomotives or motor trucks are passing or pulling up. They should not be opened again until the locomotive has passed or the truck has passed or stopped and the motor has been turned off. Truck motors should not be started while the magazine door is open.

115. Magazines and magazine areas.—*a. Magazines.*—Magazines should be designed, constructed, and located with special attention to the class of materials to be stored therein and should comply with the following general requirements:

(1) Magazines should be constructed of materials which, in the event of an explosion, will not form dangerous missiles or firebrands.

(2) Magazines should be fireproof unless the nature of the hazard permits the use of a frame building covered with fire-resistant material such as corrugated sheet asbestos.

(3) Each magazine should be provided with ventilators which should be well screened against sparks.

(4) All doors should be made to fit tightly so as to seal against sparks, dust, and dirt, and should be covered with fire-resistant material.

(5) Magazines should be built on well-drained ground.

(6) Magazines must be located so as to be accessible to adequate transportation facilities.

(7) Magazines must be protected against lightning.

b. New construction.—The Chief of Ordnance has prepared drawings and specifications for magazines. The construction of new buildings or magazines for the storage of explosives and ammunition will be in accordance with such drawings. Lay-out plans for proposed magazine areas and their location on a reservation must be approved by the Chief of Ordnance.

c. Magazine areas.—(1) It is essential that explosives and ammunition be segregated in an area specifically set aside for their exclusive storage. This area need not be large, but it is important that it be segregated from barracks, hospitals, administration buildings, public highways, inhabited buildings, and railroads. Individual magazines must be separated by distances adequate to prevent propagation of an explosion from one to another. Such distances are given in paragraph 116.

(2) A magazine area must be inclosed with a "climb proof" fence

and should be posted to show the presence of explosives and to prohibit smoking, trespassing, and hunting.

Caution: As signs are often used for targets, they should not be attached directly to magazines as many explosives may be ignited, exploded, or detonated by penetration of a rifle bullet.

(3) Fences should always be maintained in good condition and a guard stationed at every unlocked gate.

(4) Vegetation should be controlled and leaves, grass, and rubbish removed from the area and burned.

(5) Accumulation of trash, empty boxes, scrap lumber, or any such inflammable material should not be permitted.

(6) A 50-foot firebreak should be established around each aboveground magazine.

(7) Smoking, the carrying of matches, and the use of lights other than approved electric lights are forbidden.

(8) Magazine areas should be laid out with regard to access from more than one direction; roads and tracks should be looped. Water supply should be from a network of mains rather than from a single pipe line in order to insure against an important section being cut off.

(9) Magazines should not be located over important water mains or close enough to important power lines to damage them in case of an explosion.

d. Care and maintenance.—Regular inspection will be made of each magazine and magazine area to see if repairs are needed and to make sure the safety regulations set forth herein are strictly followed.

(1) Roofs should be maintained in the best possible condition and ventilators screened against sparks. There should be no unprotected openings around the foundation and no cracks in the walls. Doors should be tight and sparkproof.

(2) Interiors of magazines should be clean. Paint, oil, gasoline, waste, rags, and other inflammable material should not be left in magazines.

(3) Floors should be free of grit and such stains as those caused by exuding shell or dynamite. Exudate from shell should be removed by scrubbing with hot water. Exudate or oily stain from dynamite should be removed by scrubbing with a solution of 2 pounds of sodium or potassium sulfite in ½ gallon each of water and wood alcohol.

(4) The 50-foot firebreak should be maintained free from inflammable materials. Fire-fighting equipment such as water barrels and sand boxes should be kept full and ready for use.

(5) Magazines should be kept locked except when opened for necessary operations or inspections.

(6) When open, a magazine should be in the personal care of an officer or other responsible person, other than the nearest sentry.

(7) Keys should be in the care of the responsible officer or noncommissioned officer.

(8) The person in charge of operations should make sure that all doors and shutters are securely locked when leaving the magazine.

(9) A magazine placard, "Storage and Care of Explosives" (O. O. No. 5991), should be posted in every magazine in such position that it will be conspicuous to all personnel working therein.

c. Repairs.—(1) Magazines will be repaired under the direct supervision of a competent person who will decide whether or not the contents of the magazine are to be removed while repairs are made. Under normal conditions, roofs, lightning rods, ventilators, doors, etc., may be repaired and minor repairs to the interior of the magazine may be made without removing the contents. This does not apply to magazines containing high explosives in bulk or black powder.

(2) When magazines are repaired, the general safety regulations set forth will be complied with. In addition, the following special regulations will be observed:

(*a*) Work will be done by careful, experienced workmen.

(*b*) Nonsparking tools will be used if practicable.

(*c*) The floor in the vicinity of the work will be swept and any stains scrubbed with hot water.

(*d*) No work requiring soldering, melting of asphalt, or any use of a blowtorch will be done in a magazine containing explosives or ammunition.

(*e*) No repairs will be made to the interior of a magazine containing bulk explosives until all explosives have been removed and the interior washed with water.

(*f*) All workmen should be searched for matches before being allowed to enter any magazine.

(*g*) All magazines should be carefully swept after repairs have been completed and all tools should be removed.

(*h*) The magazine will be inspected by competent authority after repairs have been completed.

116. Quantity-distance classes and tables.—*a.* To reduce to a minimum the hazards and risks due to fire and explosion, these regulations are prescribed:

(1) The distances that will be maintained between magazines at military establishments and public highways, public buildings, public railways, and inhabited buildings.

(2) The distances that will be maintained between magazines.

(3) The maximum quantity that will be permitted in any one magazine.

b. These precautions not only protect persons and property in the territory adjacent to military establishments, but also reduce to a minimum the possibility of any explosion involving large masses of explosives and ammunition, and limit the quantity of military supplies that may be lost in any one explosion.

(1) In time of war, military requirements may make full compliance with safety regulations impracticable. Since the purpose of these regulations is to reduce to a minimum the losses to personnel and stores, the intent of the regulations will be complied with as far as practicable.

(2) In time of peace, the quantity-distance tables set forth below will be strictly complied with except when subject to reductions under special conditions as indicated below and in case of existing emplacement magazines at harbor defense installations. Such harbor defense magazines may be used for the storage of ammunition pertaining to the armament of the emplacement and not in excess of its war reserve allowance. Magazines of emplacements which have had their armament removed or become obsolescent may be used for the storage of any class of ammunition and explosives, provided the quantity-distance tables are complied with.

c. The distances specified in these tables offer protection against structural damage and most missiles. Occasional missiles which travel a mile or more are not considered because of their rarity—especially when the amount of material involved in one explosion is limited by keeping piles small and spacing them so as to limit the explosion to one pile. It will be noted that the distances specified in the tables are not based on the total amount of explosives in the magazines but upon the missile hazard and the amount that may be involved in one explosion. The specified distances may be changed under the following special conditions:

(1) When a magazine is effectively barricaded or screened from other buildings, magazines, railroad, and highway, the distances may be reduced one-half in cases not specifically forbidden in the tables. Effective screening will be by natural features of the ground or by an artificial barricade at least 4 feet from the magazine, at least 3 feet thick at the top, at least high enough so that the straight line extended from the top of the side wall of the magazine to the top of the barricade will pass above any part of a building to be protected and at least 12 feet above any public highway or public railway.

(2) Magazines of standard earth-covered concrete arch type and emplacement magazines are considered barricaded on all sides except

that of the entrance, which side may be barricaded if local conditions require.

(3) Harbor defense emplacement magazines in a group, being separated from each other by substantial dividing walls, need not comply with the intermagazine distances. However, each magazine, as a unit, must comply with the table distances for inhabited building, public highway, and public railroad.

(4) Where the construction of the magazine is such as effectually to stop the missiles resulting from an explosion therein, the distances prescribed for class 9, bulk explosives, may be used in place of those prescribed for the class to be stored. Such magazines are the standard earth-covered concrete arch type (igloo) and emplacement magazines. The quantity to be considered will be the total quantity to be stored in the magazine except where specific cases are excepted in (5) below.

(5) (*a*) The distances prescribed for quantities of explosives and ammunition of classes 3, 4, and 5 (defined below), stored in magazines similar to the prescribed ordnance types, may be computed by taking the actual weight of explosive material contained in each item and multiplying by the number of such items. The amount contained is shown in pertinent Technical Manuals and regulations and ordnance drawings which are available on request from the Chief of Ordnance. If the distances for such quantities of explosive or combinations of explosives are greater than the distances prescribed for the same amount of bulk explosive, as shown in the table for classes 9 and 10, the lesser distance may be taken as the minimum safe distance.

(*b*) Components of class 6 should be stacked in piles each containing not more than 5,000 pounds of explosive material and having at least 2 feet clearance from all other piles. In this case the quantity to be considered is the amount in one pile. If this regulation cannot be complied with, the distances for classes 9 and 10 will govern and the total amount of explosives in the magazines will be taken as the quantity. The maximum quantity permitted, however, will be 10,000 pounds or the numerical limit, whichever is less.

(*c*) Ammunition in group 7 will be stored in piles with not more than 15,000 pounds of explosive in each pile or row. The manner of piling and the distances to be maintained between piles will be in accordance with O. O. drawing 19-48-12 (figs. 63 and 64). The quantity of ammunition to be considered will then be the maximum quantity in any one pile, and distances may be reduced accordingly, provided that the lateral (side to side) distances are in excess of 16 feet. Where this distance is less than 16 feet the total quantity will be the maximum quantity in any row. Where compliance with such conditions and clearances is omitted, as is sometimes necessary in

underground magazines, the total amount of explosive material in the magazine and the distances to be observed will be taken from the table for classes 9 and 10.

d. The terms used in the following tables are defined as follows:

(1) *Inhabited building.*—Any building regularly occupied or customarily used as a habitation, church, schoolhouse, office, hospital, railroad station, or for purposes of assembly, except buildings on a military reservation where essential military requirements necessitate sites close to a magazine. The land limits or boundaries of military reservations will be considered possible sites of inhabited buildings.

(2) *Public railway.*—Any steam, electric, or other railroad which carries passengers for hire.

(3) *Public highways.*—Any street, alley, road, or navigable stream.

(4) *Navigable stream.*—A body of water capable of extensive navigation by tugs, barges, and other large vessels.

(5) *Nearest magazines.*—The nearest magazines containing explosives or ammunition. The amount of explosives or ammunition permitted to be stored in a magazine can sometimes be increased if the nearest magazines are filled with inert materials, thus greatly increasing the distances to the nearest magazine containing explosives or ammunition.

(6) *Maximum permitted.*—The largest amount of explosives or ammunition permitted to be stored in a magazine even if it is more isolated than the tables prescribe. It is imperative that the loss of military supplies be reduced to an absolute minimum.

(7) *Structural damage.*—The serious weakening or displacement of foundations or brick or stone supporting walls or the breaking of wooden main supporting members in outside or inside walls. No readily reparable damage such as broken glass or loosened plaster is considered structural damage.

e. The explosive contents of ammunition or components are shown in the Technical Manuals for each caliber and type of gun. They are also shown on ordnance office drawings. If such information is not available, it will be requested from the Chief of Ordnance. The quantities shown in the tables were computed in the following manner:

(1) *Smokeless powder.*—The quantities in pounds are the net weights of the powder in the boxes or in the propelling charges.

(2) *Pyrotechnics.*—The quantities are the gross weights of boxes and contents.

(3) *Separate and unfixed shell and bombs.*—The quantities are computed by taking the net weight of explosive in the charge of one shell and multiplying by the number of shell or bombs in the magazine.

(4) *Fixed ammunition.*—The quantity is the net weight of the high explosive charge in the shell multiplied by the number of rounds. The smokeless powder propelling charge is so much less hazardous, that it is not included in the computation for this class of ammunition.

f. The grouping of explosives and ammunition into classes in this section means that the hazards are similar for all items of a group. It does not imply that the items of a class are intended to be stored together or even that it is permitted that they be stored together. Combination storage is discussed in paragraph 117.

g. When military explosives and ammunition are packed in accordance with the provisions of War Department drawings and specifications, they may be grouped, according to the degree of hazard involved, into the following classes:

(1) *Class 1. Small arms ammunition and mechanical time fuzes without boosters.*—This is principally a fire hazard and no limit has been placed on the storage of this class, except the limit on number of fuzes. See note (³) to table for class 3.

(2) *Class 2. Smokeless powder, pyrotechnics, and chemical ammunition containing phosphorus.*—These materials under extreme conditions of moisture, high temperature, or age may become unsafe. They burn with intense heat but do not usually form dangerous missiles or generate pressures which will cause serious structural damage to adjacent magazines.

Quantity-distance table for class 2

Quantity; pounds of explosives (not over)	Unbarricaded distance [1] in feet from nearest—			
	Inhabited building	Public railway	Public highway	Magazine
10,000	150	150	150	100
100,000	300	300	300	200
200,000	375	375	375	250
500,000 [2]	600	600	600	400

[1] Reduction of distances to one-half for barricades is permitted only in the case of concrete igloo or emplacement magazines.
[2] Maximum permitted in any one magazine.

(3) *Class 3. Point-detonating fuzes, minor caliber base detonating fuzes, powder train and antitank mine fuzes, packed separately in boxes; bomb fuzes, packed with fin assemblies.*—These usually explode progressively, not more than a box or two at a time. Pressures that will cause structural damage to adjacent magazines are usually not generated. Missiles are small and light and usually fall within 100 yards.

Quantity-distance table for class 3

Quantity; pounds of explosives (not over)	Distance [1] in feet from nearest—			
	Inhabited building [2]	Public railway [2]	Public highway [2]	Magazine
50	400	400	400	60
200	400	400	400	100
1,000	400	400	400	180
10,000 [3]	400	400	400	300

[1] These distances will not be reduced by barricades except that one-half the above distances is authorized for concrete igloo or emplacement magazines.
[2] Distance that missiles will travel.
[3] Maximum weight permitted in one magazine. However, not more than 50,000 fuzes of any one model, nor more than 150,000 fuzes of any number of models, will be stored in one magazine without prior approval of the Chief of Ordnance.

(4) *Class 4. Fixed and semifixed high explosive shell, trench mortar ammunition, fragmentation bombs in wooden containers, grenades, shrapnel of all calibers, fuzed and unfuzed, and blank ammunition for cannon—packed in boxes or bundles.*—Articles in this class usually explode progressively only a few boxes at a time and many explosions of individual rounds are of a very low order. Pressures which will cause structural damage to adjacent magazines are usually not generated. Most missiles will fall within 200 yards.

Quantity-distance table for class 4

Quantity; pounds of explosives (not over)	Unbarricaded distance [1] in feet from nearest—			
	Inhabited building	Public railway	Public highway	Magazine
50	1,200	1,200	1,200	60
500	1,200	1,200	1,200	140
1,000	1,200	1,200	1,200	180
50,000	1,200	1,200	1,200	225
500,000 [2]	1,200	1,200	1,200	300

[1] These distances will not be reduced by barricades except that one-half of these distances is authorized for concrete igloo and emplacement magazines.
[2] Maximum permitted to be stored in any one magazine.

(5) *Class 5. Separate-loading and unfixed shell, loaded with explosive D, fuzed or unfuzed.*—These usually explode one shell at a time and, in nearly all cases, with low order. The missiles are limited as to number and range, and most of them fall within 400 yards.

Quantity-distance table for class 5

Quantity; pounds of explosives (not over)	Distance [1] in feet from nearest—			
	Inhabited building	Public railway	Public highway	Magazine
1,000	1,200	1,200	1,200	100
25,000	1,200	1,200	1,200	200
650,000 [2]	1,200	1,200	1,200	300

[1] These distances will not be reduced by barricades except that one-half of these distances is authorized for concrete igloo and emplacement magazines.
[2] Maximum permitted to be stored in any one magazine.

(6) *Class 6. Major and medium caliber base-detonating fuzes, bomb fuzes, boosters and bursters for high explosive and chemical shell and bombs—packed separately in boxes.*—These usually explode progressively by piles. Structural damage caused by the pressures generated is usually limited to adjacent magazines. Missles are light and usually fall within 200 yards. When items of this class are stored in concrete igloo magazines, the quantity-distance requirements of Class 9, bulk explosives, will govern. The quantity to be considered will be determined in accordance with *c*(5) (*b*) above.

Quantity-distance table for class 6

Quantity; pounds of explosives (not over)	Distance [1] in feet from nearest			
	Inhabited building	Public railway	Public highway	Magazine
50	240	140	70	60
200	240	140	70	100
5,000	1,500	900	450	200
100,000 [2]	1,500	900	450	300

[1] These distances will not be reduced by barricades nor by storage in concrete igloo or emplacement magazines.
[2] Maximum weight permitted in one magazine. However, not more than 50,000 fuzes of any one model nor more than a total of 170,000 fuzes of any number of models will be stored in one magazine without prior approval of the Chief of Ordnance.

(7) *Class 7. Separate and unfixed shell of all calibers, except those loaded with explosive D.*—All in a magazine may explode but the explosion may be limited to one pile by arranging the material in accordance with instructions for piling separate loading shell given in *c*(5) above and paragraph 118*g*(2). Structural damage is usually limited to adjacent buildings. Most missiles will fall within 500

yards. When items of this class are stored in concrete igloo magazines, the quantity-distance requirements of Class 9, bulk explosives, will govern. The quantity to be considered will be determined in accordance with *o*(5) (*c*) above.

Quantity-distance table for class 7

Quantity; pounds of explosives (not over)	Distance [1] in feet from nearest—			
	Inhabited building	Public railway	Public highway	Magazine
25,000	1,800	1,800	1,800	200
500,000 [2]	1,800	1,800	1,800	300

[1] These distances will not be reduced by barricades nor by storage in concrete igloo or emplacement magazines.
[2] Maximum permitted in any one magazine.

(8) *Class 8. Primers, primer-detonators for bombs, grenade fuses, and blasting caps—packed in metal containers and wooden boxes.*—All in a magazine may explode at one time but as the total amount of explosives is small and they are not closely confined, structural damage is usually limited to adjacent magazines. Light missiles are formed which have a very limited range.

Quantity-distance table for class 8

Quantity; pounds of explosives (not over)	Distance in feet from nearest—			
	Inhabited building	Public railway	Public highway	Magazine
50	240	140	70	60
500	720	430	220	140
2,000	980	590	300	300
5,000	1,200	720	360	300
10,000	1,500	900	450	300
15,000	1,610	970	490	300
20,000 [1]	1,740	1,040	520	300

[1] Maximum weight permitted to be stored in any one magazine.

(9) *Class 9. Flashlight powder, demolition blocks, spotting charges, bulk low explosives, bulk priming explosives, bulk initiating explosive such as tetryl, bulk high explosives such as TNT and explosive D.*

(10) *Class 10. Demolition bombs, fragmentation bombs in metal crates, photoflash bombs, and HE antitank mines.*—All in a magazine may explode at one time. If this happens, structural damage, caused

by the pressures generated, is not likely to occur at the distances given in the table and most missiles will fall well within these distances.

Quantity-distance table for classes 9 and 10

Quantity; pounds of explosives (not over)	Distance in feet from nearest			
	Inhabited building	Public railway	Public highway	Magazine
50	145	90	45	60
100	240	140	90	80
200	360	220	110	100
300	520	310	150	120
400	640	380	190	130
500	720	430	220	140
600	800	480	240	150
700	860	520	260	158
800	920	550	280	165
900	980	590	300	170
1,000	1, 020	610	310	180
1,500	1, 120	680	340	210
2, 000	1, 200	720	360	230
3, 000	1, 320	790	390	260
4,000	1, 420	850	420	280
5,000	1, 500	900	450	300
6,000	1, 560	940	470	300
7,000	1, 610	970	490	300
8,000	1, 660	1, 000	500	300
9,000	1, 700	1, 020	510	300
10,000	1, 740	1, 040	520	300
15,000	1, 870	1, 120	560	300
20,000	2, 010	1, 200	600	300
25,000	2, 140	1, 290	640	300
30,000	2, 280	1, 370	680	300
40,000	2, 550	1, 530	760	300
50,000	2, 800	1, 680	840	300
75,000	3, 310	1, 990	1, 000	400
100,000	3, 630	2, 180	1, 090	400
150,000	3, 800	2, 280	1, 140	800
200,000	4, 060	2, 440	1, 220	800
250,000 [1]	4, 310	2, 590	1, 300	800

[1] Maximum permitted in any one magazine.

(11) *Class 11. Chemical ammunition, except ammunition containing phosphorus.*—Chemical shell, bombs, and grenades stored and issued by the Ordnance Department are not considered to be an explosive hazard and no limit has been placed on this type of ammunition as far as quantities and distances are concerned. However, there

are restrictions on the storage of such ammunition which are set forth in paragraphs 117 and 118*k*.

(12) *Class 12. Explosives such as ammonium nitrate, DNT, and wet nitrocellulose.*—These materials are insensitive and can be detonated only by very strong initiation. When stored in an explosives area where there is a possibility that explosives may be projected into them, they will be stored in accordance with the regulations for Class 9 explosives. When stored in an area of fire hazards only and separated by inhabited building distances from areas containing explosives or ammunition, these materials may be stored in accordance with the regulation for smokeless powder.

117. Storage chart—combination storage.—*a. Storage chart.*—(1) The following chart shows the explosives and ammunition which may be stored together subject to the quantity-distance tables, paragraph 116. The X in the intersection of a horizontal row and a vertical column indicates that these items may be stored together. As one example, small-arms ammunition may be stored with pyrotechnics. Where the X appears in all of the intersections within a group, any or all of the items in the group may be stored together. For example, any or all of the items in group C may be stored in one magazine.

(2) When two items are stored together in accordance with this rule, additional items may be stored therewith only if each of the additional items is authorized for storage with all of the other items. For example, if small-arms ammunition and pyrotechnics are stored together, antitank mine fuzes may not be added because the chart does not authorize the storage of antitank mine fuzes with pyrotechnics.

(3) Where the X does not appear at the intersection of a row and a column, the two items may not be stored together in one magazine except in the cases and under the conditions noted in *b* below.

STORAGE CHART

GROUPS See paragraph 117 for use of chart and exceptions		Bulk black powder, saluting, practice bomb and smoke puff charges	TNT (bulk) and demolition blocks	Dynamite	Explosive D	Smokeless powder, bulk or charges	Small-arms ammunition	Fixed and semifixed HE shell and shrapnel	Blank ammunition for cannon	Separate loading shrapnel	Fragmentation bombs (wood crates)	Light mortar shell (81-mm and less)	Grenades, fragmentation and practice	Antitank mines, practice	Fuzes, time and detonating	Primers and primer detonators	Detonators, blasting and percussion caps	Grenade fuzes	Adapters, boosters, and bursters	Fuzes, antitank mine	Demolition bombs	Fragmentation bombs (metal crates)	Separate loading shell	Antitank mines, HE	Pyrotechnics
A	Bulk black powder, saluting, practice bomb, and smoke puff charges	X																							
A	TNT (bulk) and demolition blocks		X		X																				
A	Dynamite			X																					
A	Explosive D		X		X																				
B	Smokeless powder, bulk or charges					X																			
C	Small-arms ammunition						X	X	X	X	X	X	X	X	X	X	X	X	X	X					X
C	Fixed and semifixed HE shell and shrapnel						X	X	X	X	X	X	X	X											
C	Blank ammunition for cannon						X	X	X	X	X	X	X	X											
C	Separate loading shrapnel						X	X	X	X	X	X	X	X											
C	Fragmentation bombs (wood crates)						X	X	X	X	X	X	X	X											
C	Light mortar shell (81-mm and less)						X	X	X	X	X	X	X	X											
C	Grenades, fragmentation and practice						X	X	X	X	X	X	X	X											
C	Antitank mines, practice						X	X	X	X	X	X	X	X											
D	Fuzes, time and detonating						X								X	X	X	X	X	X					
D	Primers and primer detonators						X								X	X	X	X	X	X					
D	Detonators, blasting and percussion caps						X								X	X	X	X	X	X					
D	Grenade fuzes						X								X	X	X	X	X	X					
D	Adapters, boosters, and bursters						X								X	X	X	X	X	X					
D	Fuzes, antitank mine						X								X	X	X	X	X	X					
E	Demolition bombs																				X	X			
E	Fragmentation bombs (metal crates)																				X	X			
F	Separate loading shell																						X		
G	Antitank mines, HE																							X	
H	Pyrotechnics						X																		X
I	Chemical amm., gr. A (vesicant)	Stored separately																							
J	Chemical amm., gr. B (gas and smoke)	Stored separately																							
K	Chemical amm., gr. C (phosphorus)	Stored separately																							
L	Chemical amm., gr. D (burning)	Stored separately																							
M	Bombs, photoflash	Stored separately																							
N	Flashlight powder	Stored separately																							

at night and closing them in the morning. If this fails to reduce the temperature, the commanding officer will decide whether the stores are to be removed to another magazine. When magazines are cooled by such ventilation at night effective measures will be taken to protect against fire and to close the doors in case of rain.

(5) Smokeless powder, in bulk or in separate loading charges, is always packed in airtight containers. It is important that such containers remain airtight until the powder is used. When a shipment is received, every container is given a visual inspection to see that it is not damaged and that the cover is in good condition and tight.

(6) Metal containers for propelling charges are fitted with a test hole and plug in the cover so that they can be tested for airtightness. Every container in which a propelling charge is stored will be air-tested when received and whenever it is subject to handling that might cause it to leak. The testing should be done with an apparatus similar to that described in O. O. drawing 24-12-2, providing, however, that no motor-driven air compressor will be taken into a magazine in which explosives or ammunition are stored. A pressure of 3 to 5 pounds is used and if no drop in pressure is observed in one minute it may be assumed the case is not leaking.

(7) Every leaking container will be repaired or the contents transferred to an airtight container. If the contents of any container show evidence of dampness or moisture, it should be segregated and reported to the corps area or department ordnance officer. Leaks due to covers or gaskets may be repaired without removing the charge from the container or the container from the magazine, provided care is taken to guard against sparks. Repair of leaks in other parts of the container will be undertaken only after the removal of the charge from the container and the container from the magazine.

(8) Personnel engaged in air testing will be familiar with the odor and appearance of decomposing powder. They should examine each container opened for air test for the characteristic odor. One of the first evidences of dangerous deterioration is the presence of the acid odor of nitrous fumes in place of the normally present odor of alcohol-ether. The odor of decomposing powder is so characteristic that it should not be mistaken.

(9) Fiber containers of separate loading propelling charges are not opened unless they are damaged; then the charge is transferred to a serviceable metal container. Fiber containers are not repaired.

(10) Metal containers may rust. They may be repainted but must be removed from the magazine to do so. Care must be taken to reproduce faithfully the original markings whenever containers are repainted or changed.

(11) Some fine-grain smokeless powders are almost as sensitive as black powder and equal precautions should be observed. The principal safety measure in regard to smokeless powder, however, is the careful watch for deterioration.

(12) The normal odor in a smokeless powder magazine is a faint odor of alcohol-ether. If this odor is strong, it probably indicates a leaky container.

e. Small-arms ammunition.—Small-arms ammunition may be stored in any magazine or warehouse which offers good protection against the weather. When magazine space is limited, it may be stored in a general warehouse by partitioning or screening off a section for its exclusive use. This refers to small-arms ammunition only and not to other types with which it may be stored in a magazine. Good protection against moisture and high temperature should be provided. Free ventilation of all parts of the pile should be insured, dunnage being used where necessary. Skylights and windows near piles should be shaded so that ammunition will not be exposed to direct sunlight. Care should be taken to avoid piling ammunition near steam pipes. Nearly all types of small-arms ammunition are packed in boxes fitted with airtight metal liners and these liners should not be opened until the ammunition is about to be used. When only a part of a box is used the remaining ammunition in the box should be protected against unauthorized handling and use by firmly fastening the cover in place. Serviceable ammunition turned in by troops should not be stored in open boxes. It should be repacked for storing and reissued at the first opportunity, provided it can be identified by lot number. If it cannot be identified by lot, it automatically becomes grade 3 and should be reported to the corps area or department ordnance officer for disposition.

f. Fixed and semifixed ammunition, grenades, and mortar shell.—(1) These may be stored in any magazine with good protection from the weather but preferably in fireproof or fire-resistant magazines to reduce to a minimum the danger of fire or explosions. Most of the standard boxes and bundles in which this type of ammunition is packed are provided with cleats and those that are not may be piled with dunnage to insure free circulation of air. Except for 37-mm and smaller calibers, fixed ammunition is packed in individual sealed containers which are then bundled or boxed. If the ammunition is not removed from these sealed containers until it is used, it should remain in good condition. Serviceable rounds which have been removed from their containers, such as those turned in by troops, should be placed in containers which should then be sealed with friction tape and shellac before they are again placed in storage. This procedure will protect the round against deterioration and the primer against accidental blows. Loose rounds should never be permitted in a magazine.

(2) Some fixed ammunition and the limited standard HE fragmentation grenade are shipped unfuzed. Assembly of fuzes to such items is forbidden within 100 feet of a magazine containing explosives or ammunition.

(3) It is sound policy to mix quantities of different sizes and types in each of several magazines rather than to store only one kind in each magazine. For example, there may be on hand a sufficient quantity of 75-mm high explosive shell to fill one magazine and enough 75-mm shrapnel for another. Rather than store all high explosive shell in one magazine and all shrapnel in another, it is better storage practice to store half of each type in each magazine. Thus, in case of accident to one magazine, there is still a supply of both types of ammunition on hand.

g. Separate loading shell.—(1) Separate loading and unfixed shell should be stored in fireproof magazines containing a minimum of inflammable materials. Iron or steel dunnage is preferred to wood and it should be electrically connected and grounded. If it is necessary to use wood for dunnage, the amount should be kept to an absolute minimum. Unfuzed shell should be fitted with an iron or steel fuze hole plug. If it is necessary to roll fuzed shell, it should be done carefully in order to avoid the risk of arming the fuze.

(2) In order to confine an explosion to one pile of shell, the following precautions will be observed:

(*a*) Shell should be piled in single piles with the noses of the shell in one pile pointing toward the noses of the shell in the next pile and and with the bases of the shell in one pile facing the bases of the shell in the next pile. Shell up to and including 10 inches in diameter should be piled in accordance with figure 63, and distances specified should be maintained if the shell are loaded with TNT or amatol. If the shell are loaded with explosive D, the distances need be only large enough to permit inspection of the shell and of the fuze cavities.

(*b*) The nose-to-nose and base-to-base distances between rows should be equal.

(*c*) The nose-to-nose distances for each caliber shell are given in ordnance drawing 19-48-12 (fig. 63). They should be strictly observed and the number of shell in each pile should be kept to a minimum consistent with the storage space available.

(3) Shell over 10 inches in diameter may be stored on their sides or on their bases. When stored on their bases, there should be a 1-inch board between the shell and the floor to protect the shell from moisture; shell loaded with explosive D may be stored in intimate contact but

shell loaded with TNT should be separated by a distance equal to the caliber of the shell.

(4) The rotating bands on all projectiles should be carefully protected by rope grommets or some other effective means. Dents or cuts in the band may cause the shell to function improperly in the gun.

h. Bombs.—In storing bombs, a distinction must be made between the fragmentation and demolition types.

(1) Fragmentation bombs are packed in wooden boxes and metal crates. Those packed in wood are not liable to detonate in mass if a fire occurs in the magazine in which they are stored. These are stored with, and in a manner similar to, fixed ammunition. Fragmentation bombs in metal crates are stored with, and in the same manner as, demolition bombs.

(2) Demolition bombs have comparatively thin walls and comprise one of the most hazardous types of ammunition to store because of their tendency to detonate in mass if a fire occurs in, or a heated fragment be projected into, the magazine in which they are stored. Safety can be obtained only by reducing the possibility of fire to the absolute minimum. Demolition bombs should be stored in a fireproof magazine with iron or steel dunnage. If wood must be used for dunnage, the amount should be kept to a minimum. Steel dunnage should be connected electrically and grounded to the lightning protective system of the magazine. Demolition bombs not intended for immediate shipment should be unpacked and stored as above. Boxes and crates should be stored separately in a warehouse and fuzes or primer-detonators should be stored in a separate magazine.

(3) Bombs with fins attached should be piled with care not to bend or otherwise damage fins and all demolition bombs should be piled so that the fuze cavity can be easily inspected.

i. Fuzes, primers, primer-detonators, detonators, and boosters.—These components are usually packed in hermetically sealed containers and boxes. Care should be taken in packing to see that they are properly supported in racks or trays and protected against shock or rough handling. Even when properly packed, this class of components should be handled with great care. Boxes should be stored top up, in double row stacks, with 24-inch aisles between stacks and between outside stacks and walls. Partly filled boxes should be kept securely closed. Magazines for the storage of fuzes should be small to limit the loss of this type of material, and the quantity of fuzes, primers, etc., stored in any one magazine should be kept to a minimum, consistent with the storage space available. Storage of all on hand of any one type in a single magazine is to be avoided if possible.

j. Pyrotechnics.—Pyrotechnics require protection against moisture, dampness, and high temperature. Pyrotechnic material that has been wet is hazardous to store, consequently any boxes that show signs of dampness will be opened and if the pyrotechnic material is wet, it should be destroyed (see ch. 4). Pyrotechnics should be handled with care even when properly packed. Certain kinds of this material deteriorate in storage and have an expiration date on the containers. Care should be taken to observe the direction for disposal of this material at the time indicated.

k. Chemical ammunition.—(1) Chemical ammunition should not be stored with other classes, principally because of the difficulty and danger encountered in fighting a fire involving chemical materials. All munitions containing chemical agents are stored in such a manner that each item is accessible for inspection and may be easily removed from storage in case it should develop a leak. This type of ammunition must be inspected for leaks once a month and any leaking container is removed downwind to await disposal.

(2) Whenever a magazine containing chemical ammunition is opened, a responsible officer or foreman should be present to detect the odor of escaping gas. If such an odor is present, all persons entering the magazine will wear the protective devices proper for the group, all windows and doors of the magazine will be opened, and the leaking container sought out and removed.

(3) Each type of chemical ammunition is preferably stored alone, but may be stored with other chemicals having similar properties. The special equipment, as listed for each group of chemical agents, should be available in the vicinity, but not in the magazine. The chemical agents are grouped as follows:

(*a*) *Group A. Vesicants, HS and M1.*—Magazines for this group should have surface-hardened concrete floors. Special equipment should include gas mask, protective suit, boots, and gloves for each officer, man, or fireman whose duties require his presence in the magazine; chloride of lime, kerosene and flannel cloths, sodium bicarbonate, boric acid, soap, and ample washing facilities.

(*b*) *Group B. Toxic, irritant, and smoke-producing chemical munitions.*—Magazines should have surface-hardened concrete floors and free ventilation. Special equipment should include gas masks, gloves, saturated solution of sodium sulfite, saturated alcoholic solution of sodium hydroxide, litters, and wool blankets. Masks will be carried at all times by personnel in the magazine.

(*c*) *Group C. Spontaneously inflammable munitions, phosphorus, WP.*—This type magazine should have concrete floors with elevated sills to permit flooding. Special equipment includes tubs or barrels

filled with water and large enough to contain the largest component stored. In addition, there should be available rubber gloves and boots, sponges, pails, and copper sulfate solution.

(*d*) *Groups D. Incendiary and readily inflammable substances, TH, FS, HC, CN, CN-DM grenades.*—No water is to be used in this magazine. No special precautions are necessary except to keep water and fire away, and to remove leaking containers to prevent an accumulation of loose material in the magazine.

(4) Munitions from two or more groups will not be stored together without the specific approval of the Chief of Ordnance.

l. Inert materials.—Inert materials or empty components of ammunition such as drill cartridges, target-practice projectiles, or empty shell should be stored in buildings which afford good protection against moisture and dampness. They should be cleaned, repainted, and slushed when necessary and should not be allowed to deteriorate. Shell should be carefully stored to guard against damage to the rotating band.

CAPACITY OF MAGAZINE																
SHELL H.E.	DRAWING NUMBER	LENGTH OF SHELL AS STORED (APPROX.)	WEIGHT OF SHELL AS STORED (APPROX.)	WEIGHT OF T.N.T. BURSTING CHARGE	DIAMETER OF SHELL	SHELLS PER ROW			POUNDS OF EXPLOSIVE PER ROW	NUMBER OF ROWS	NOSE TO NOSE BASE TO BASE AISLE SPACE	NUMBER OF SHELLS PER MAGAZINE	TOTAL POUNDS OF EXPLOSIVE PER MAGAZINE	DIMENSION B
						LONG	HIGH	TOTAL						
6" GUN MK. II	75 - 7 - 42	25.25"	91.00	13.69	6.000"	81	X 10	= 810	11,309.22	41	38"	33,210	454,644.9	15"
155 M.M. GUN MK. III	75 - 14 - 138	25.54"	94.86	15.17	6.080"	80	X 10	= 800	12,187.20	39	41"	31,200	473,304	17"
155 M.M. GUN MK. III A1	75 - 14 - 228	26.88"	95.76	15.210	6.080"	80	X 10	= 800	12,168.00	38	41"	30,400	462,384	23"
155 M.M. GUN M.101	75 - 14 - 229	26.79"	94.32	15.560	6.080"	80	X 10	= 800	12,448.00	38	41.5"	30,400	473,024	15"
155 M.M. HOW MK. I	75 - 14 - 137	25.54"	94.86	15.17	6.080	80	X 10	= 800	12,187.20	39	41"	31,200	473,304	17"
155 M.M. HOW MK. I A1	75 - 14 - 231	26.88"	95.38	15.210	6.080"	80	X 10	= 800	12,168.00	38	41"	30,400	462,384	23"
155 M.M. HOW. M.102	75 - 14 - 232	26.79"	93.88	15.560	6.080"	80	X 10	= 800	12,448.00	38	41.5"	30,400	473,024	15"
8" GUN & HOW.	75 - 4 - 23	31.00"	197.75	29.902	8.000"	60	X 8	= 480	14,352.96	33	48"	15,840	473,647.68	12"
240 M.M. HOW. MK. III	75 - 14 - 139	37.44"	344.85	49.492	9.425"	51	X 7	= 357	17,668.64	27	59.5"	9,639	477,053.38	13"
10" GUN MK. IV	75 - 9 - 16	43.93"	518.00	73.742	10.000"	48	X 5	= 240	17,698.08	25	59.5"	6,000	442,452	29"

THE ABOVE TABLE IS BASED ON THE STANDARD MAGAZINE, 48 FEET BY 217 FEET.

THE ABOVE TABLE IS FOR SHELL LOADED WITH T.N.T. OR AMATOL. SHELL LOADED WITH EXPLOSIVE "D" MAY BE PILED IN THE SAME MANNER, BUT AISLE SPACES NEED ONLY BE SUFFICIENT FOR INSPECTION AND HANDLING.

THE DISTANCES BETWEEN PILES ARE DESIGNED TO LIMIT EXPLOSIONS TO ONE PILE.

CAUTION:- SEE ORDNANCE SAFETY MANUAL O.O. FORM 7224 AND ORDNANCE DEPARTMENT DRAWING 19-48-12 FOR OTHER ESSENTIAL DETAILS.

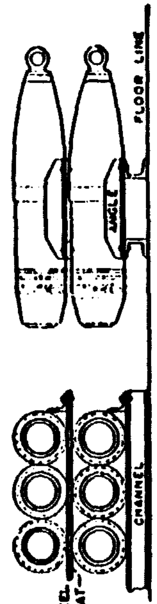


FIGURE 63.—Piling and storage data for separate loading and unfixed projectiles.

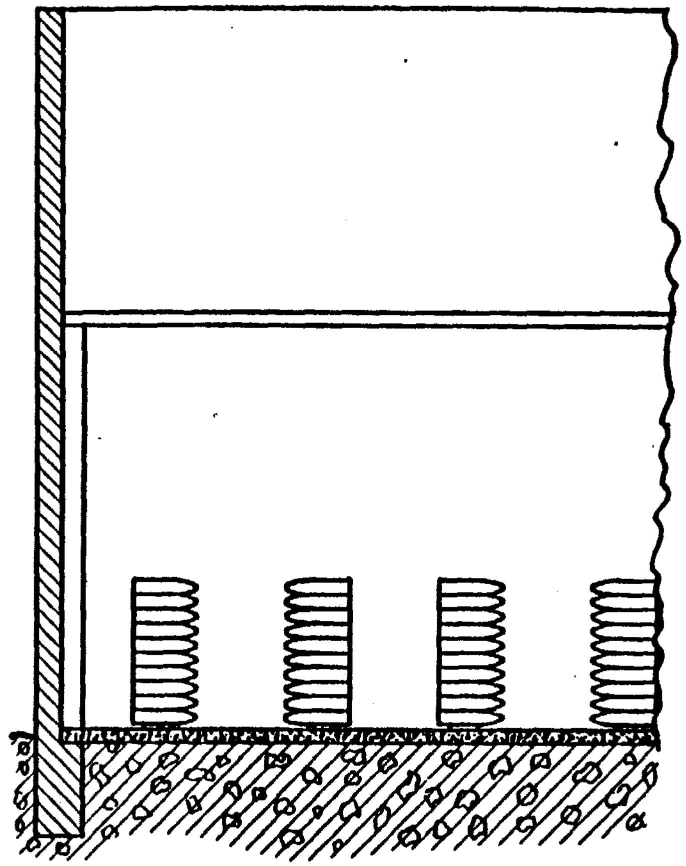


FIGURE 64.—Method of piling shell.

SECTION III

INSPECTION AND SURVEILLANCE

119. Definitions. *a. Inspection.* Periodic tests for the purpose of detecting signs of deterioration and determining the condition and serviceability of stocks on hand.

b. Maintenance.—The care taken and work done to keep the ammunition in good condition.

c. Surveillance.—Combination of inspection and maintenance.

d. Grading.—See paragraph 9.

120. Inspection of magazines and magazine areas.—*a.* Magazines and magazine areas should be inspected once a month to see that all conditions are normal, that neither humidity nor temperature is or has been too high, and that containers are in a satisfactory condition.

b. The following is a summary of conditions that should apply when ammunition is inspected:

(1) The location of magazines should conform to the quantity-distance tables in regard to distance from inhabited buildings, from public highways and railroads, and from each other.

(2) The magazine area should be well guarded and protected against fire.

(3) The required firebreaks should be provided and free from rubbish and inflammable material.

(4) The magazines should be well and suitably constructed.

(5) The magazines should be in good repair, dry, and well ventilated.

(6) The interiors of magazines should be clean and neat with stores arranged in orderly piles.

(7) The requirements of the storage chart, paragraph 117, should be met.

(8) The stores should be properly identified by lot number and piled with no more than one lot in each pile.

(9) Boxes should be securely closed.

(10) Loose rounds, damaged containers, empty containers, paint, oil, waste, rags, tools, and other prohibited articles should not be present in the magazine.

(11) All ammunition, explosives, and loaded components (except small-arms ammunition) should be stored in segregated magazines and not in buildings used for other purposes.

(12) Files of pertinent publications should be on hand and up-to-date.

121. Smokeless powder.—*a.* Smokeless powder in bulk and separate loading propelling charges should be inspected to see that all containers have lids fastened firmly in place, that containers are air-tight and in good condition. They should be examined for evidence of having been subjected to moisture and dampness and, in warm weather and climates, the records of the maximum-minimum thermometer examined. Metal containers of separate loading propelling charges should be air tested. Air testing personnel should be familiar with the odor of decomposing powder and should note carefully the odor from each container as it is opened for air test.

b. When smokeless powder reaches an age at which it may be expected to deteriorate with increased rapidity, each container is inspected at least every 12 months. Methods of inspection and tests to be performed are laid down each year by the Chief of Ordnance and published in OFSB 3-13.

c. During inspection, minor repairs such as tightening lacings and replacing gaskets should be effected.

d. In large magazines, instead of dating each methyl violet test paper individually, a record may be kept in the magazine of the date of inspection. If any lots containing such undated papers are shipped elsewhere, the date of last inspection which normally appears on the test paper will be shown on the shipping ticket.

122. Fixed and semifixed ammunition and grenades.—*a.* All stocks on hand should be inspected to see that they can be readily identified as to kind and lot number and that the ammunition has not been subjected to moisture and dampness. Boxes should be examined to see that they have not been opened nor individual rounds removed from their sealed containers. Serviceable rounds turned in by troops should be examined to see that they have been properly repacked and sealed. Unserviceable rounds on hand should be examined to see that they are packed in closed boxes and inquiry made to ascertain that they have been reported for disposition.

b. Representative rounds of lots that have been in storage for more than 1 year should be examined as described below.

(1) One round of ammunition will be selected at random from each of three packages representative of each lot. These rounds should be removed from the magazine and disassembled with care. Immediately after the shell is removed from the cartridge case, the odor from the powder will be noted. All instances of the odor of nitrous fumes will be reported.

(2) Pour out the powder into a separate pile for each round and inspect for deteriorated grains. The most common indication of deteriorated grains is the appearance of reddish yellow spots which gradually spread over the grain until the entire grain is the same

color. This orange-colored section is brittle and friable and has a dull surface. There is another type of deteriorated grain having a reddish, translucent, waxy appearance; however, this type should not be confused with the normal amber-colored grain which is characteristic of some lots of smokeless powder. In general, any charge containing an excess of 1 percent deteriorated grains will have a marked odor of nitrous fumes.

(3) If no deteriorated grains are present, the round will be reassembled.

(4) If deteriorated grains are present, the percentage will be determined and reported independently for each round of the sample. If the percentage is in excess of 1 percent, a similar determination of percentage of deteriorated grains will be made in nine additional rounds.

(5) If the percentage of deteriorated grains does not exceed 1 percent, the round will be reassembled; if over 1 percent the smokeless powder from that round will be destroyed, the primer fired, and the balance of the round shipped to the nearest ordnance depot.

(6) Since it is very difficult to discern deteriorated grains in graphited, FNH, or NH powders, rounds containing such powders will be tested for odor only. If acid odor is detected the round will be disposed of as indicated in (5) above for deterioration above 1 percent.

(7) Semifixed ammunition will be inspected as described above except that, when the charge is contained in bags, the bags only will be inspected for orange or brown spots or total discoloration. Rounds containing bags which are discolored or spotted due to deteriorated smokeless powder will be disposed of as described above for deterioration above 1 percent.

(8) Propelling charges of 3-inch mortar shell will be examined for ability to stand assembly to the shell. The samples taken should be three cans from each lot and, if unsatisfactory, an additional 1 percent of the lot on hand.

(9) Mortar shell and grenades are inspected as in *a* above except that extreme care is taken to see that all grenades and grenade fuzes are in boxes which are so effectively closed that the articles cannot be easily removed and handled.

(10) A report in duplicate for each lot inspected will be forwarded, through channels, to the Chief of Ordnance.

123. Small-arms ammunition.—TM 9-1990 and OFSB 3-5 should be at hand.

a. An examination should be made to see—

(1) That all ammunition on hand is properly identified.

(2) That box seals have not been broken or liners opened.

(3) That covers of partly filled boxes are firmly fastened.

(4) That an excessive quantity of grade 3 ammunition has not accumulated.

(5) That grade 3 ammunition has been reported.

(6) That there is no great accumulation of serviceable rounds of ammunition not packed in clips or bandoleers or in the regularly prescribed manner.

(7) That there is no accumulation of otherwise serviceable ammunition not identified by lot number.

b. Ammunition that has been in storage for 1 year should be inspected for corrosion, season cracking, dents, or other defects of the cartridge case, and for loose bullets or split tracer bullets.

c. Serious defects should be reported at once and if the number of defective cartridges is greater than 20 percent, the lot should be held for instructions from the Chief of Ordnance.

124. Bulk explosives.—Black powder in bulk, practice bomb and smoke-puff charges, TNT in bulk and blocks, explosive D, and dynamite should be examined to see that the containers are in good condition, that there are no open containers, and that explosives are not sifting from the containers. Black powder containers should be examined for rust and for evidence that containers have been opened in an improper manner, such as by the use of a cold chisel, hatchet, or other unsuitable tool. Dynamite containers should be examined for signs of exudation and other evidence of nitroglycerin on the case or on the floor.

125. Separate loading shell.—*a.* Separate and unfixed shell should be inspected to see that they are piled in the manner, and with the clearance, prescribed in these regulations. Shell should be inspected for rust or corrosion and some of the fuze hole plugs should be removed to see that the threads are not burred or rusty and that the cavity is clear. Bands should be protected against dents, cuts, and pressure from upper layers of shell. Shell should be examined to see that they are properly painted and marked as required. TNT or amatol shell should be examined for exudate. Any exudate formed on shell or the floor should be scrubbed up with hot water. Exuding shell should be reported and held for disposition. Exudate is an oily brown liquid that oozes out around the thread in the nose of a shell. It is inflammable and may carry small particles of TNT. If the exudation is slight, the corps area or department ordnance officer may permit the shell to be used after the exudate has been thoroughly cleaned off. If the exudation is excessive and drips on the other shell or the floor, the shell will not be used. Exudate should be cleaned from the projectiles and from the floor by scrubbing with hot water.

b. When it becomes necessary to recondition the exterior surfaces of projectiles, they should first be thoroughly cleaned. Metal does not stop rusting unless all signs of rust are removed from the shell. Light engine oil should be applied and cleaned off with gasoline after 2 or 3 weeks; then paint, with one coat of primer and one, or two if necessary, coats of paint. If shell are stored in damp places, district commanders may authorize the use of grease for slushing after painting or may dispense with painting entirely if, under local conditions, adequate protection can be obtained through the use of grease alone. It must be remembered that in warm weather grease must be renewed frequently. Whether painted or greased or both, provision must be made for stenciling lot numbers and other identifying marks on projectiles and storing them so that the shell may be readily identified by lot number.

126. Bombs.—The requirements for the inspection of fragmentation bombs are similar to those for fixed ammunition. Demolition bombs are inspected to see that the regulations laid down for storage are strictly complied with. Examination should be made for exudate, rust, and corrosion. Fin assemblies should be protected. Fuze hole plugs should be removed from a representative sample to see that threads and cavities are in good condition. Painting and marking should be in accordance with regulations. Exuding bombs are treated the same as exuding shell.

127. Fuzes.—Fuzes and other small loaded components should be examined to see that they are stored in sealed containers and well protected against moisture. Partly filled boxes are examined to see that they have been properly resealed. A check should be made to see that the components are suitable for use with the ammunition on hand and that the required number is available. Components which have been in storage more than 1 year will have a representative box of each lot opened and the contents examined for rust, discoloration, and corrosion. Satisfactory items are resealed by resoldering containers or sealing with friction tape and a coat of shellac. Questionable items will not be issued but will be reported to the Chief of Ordnance for disposition.

128. Pyrotechnics.—Pyrotechnics should be examined to see that all containers are in good condition, and that they are effectively closed so that the contents cannot be easily removed or handled. Some pyrotechnics have a definite date of expiration of service life marked on the package. This date should be checked and OFSB 3-9 should be consulted for disposition of overage material.

129. Chemical ammunition.—Chemical ammunition should be inspected to see that it is stored so that any leaky container can be readily removed and that facilities for handling leaky containers are

available. The ammunition is examined monthly for leaks and every 6 months for rust or corrosion. Boxes should be examined to see if there are any instructions thereon requiring the destruction or use of the contents by a certain date. Containers which develop leaks should be reported, through channels, to the Chief of Ordnance. Such reports should include information as to type, lot, date discovered, nature of leak and whether apparently caused by defective material or improper handling, and disposition made of container or disposition recommended.

130. Inert components.—Inert or empty components of ammunition should be inspected to see that they are properly protected against rust and corrosion, or if they need a renewal of a protective coating of paint or grease.

131. Report of unserviceable and defective ammunition.—*a.* When the material in the hands of troops is inspected, inquiry should be made as to any ammunition failures experienced since the date of the last inspection and whether such failures have been reported. If no report has been made through channels to the Chief of Ordnance, all available details of failures will be collected and so reported.

b. If the inspector finds defects in ammunition which will require the expenditure of labor or funds to correct, he should take care to examine a sufficient number of containers or rounds to insure a report on average conditions and not isolated cases. The examination of five containers, selected at random, should be sufficient for a report that will reflect average conditions.

132. Publication file.—A file of pertinent Technical Regulations, Technical Manuals, Field Manuals, and Ordnance Field Service Bulletins will be kept complete and up-to-date. The corps area or department ordnance officer or his assistant should determine, when inspecting ammunition at a post, camp, or station, that such files are available and their contents are thoroughly understood.

SECTION IV

PACKING AND MARKING

133. General.—*a. Purpose of packing.*—(1) In order that ammunition may reach the firing line in a serviceable condition, it is essential that each unit of issue be suitably packed to withstand handling, storage, and transportation. Once a unit of ammunition has been removed from its approved container, there is no assurance of its continued serviceability. Therefore, equal precautions should be taken in its further handling and storage.

(2) When a waterproof container is opened, the contents are immediately subject to the effects of moisture, which is the most active agent in causing the deterioration of ammunition. In case immediate use is not contemplated, steps should be taken to reseal the container.

b. Marking.—(1) Marking includes painting, stenciling, and stamping of containers and of the ammunition itself. (See par. 8.)

(2) Explosives and other dangerous articles offered for shipment on a common carrier will be marked to comply with Interstate Commerce Commission regulations.

(3) Explosives and ammunition will be marked in accordance with Army Regulations, specifications, and drawings. Standard and special markings are covered by U. S. Army specification 100-2, and are further described and explained in Technical Manuals and in other sections of this manual. Markings furnish essential information, permitting intelligent handling, storage, and issue of the round or component.

(4) New painting or remarking of ammunition and ammunition components should be a facsimile of that of the original container or ammunition unless the Chief of Ordnance issues specific instructions to the contrary. Explosives and ammunition obtained from salvage operations or matériel whose identification has been lost should be marked to show clearly the nature of the goods and, if offered for shipment, will be marked to comply with Interstate Commerce Commission regulations.

134. Packings.—*a. Design and construction.*—The design and construction of packings depend upon the type of hazard involved and the facilities for storage and transportation, and the type of protection required by the item packed.

b. Types.—(1) *General.*—Wooden boxes and crates are used more often than other types. The trend being followed in the design of boxes and crates is toward the use of standard 1-inch, or heavier, lumber. However, recently boxes of wire-bound construction using a veneer with reinforcing cleats, with strands of wire encircling the box, have been adopted as standard in several instances. Wire-bound boxes will not stand as much reuse as the heavier wooden box but their original lower cost will probably make their use more economical, particularly at times when reuse of the box would not be warranted. Corrugated or fiberboard containers are to some extent replacing the

wooden packing boxes, as in the case of some complete rounds, propelling charges, and pyrotechnics. Four general types of packing—boxes, crates, cartridge storage cases, and fiber containers—are noted below.

(2) *Boxes.*—(*a*) *End opening.*—One end being removable, these boxes can be stacked on their sides, permitting opening without necessity of removal from the stacked pile.

(*b*) *Chest type or hinged top.*—This type provides easy access to the contents and repeated use.

(*c*) *Screw top.*—This type uses screws, or bolts and nuts, to hold down the top cover. Boxes for fuzes, primers, boosters, and primer detonators should have their wooden covers fastened with screws. Nails will not be used.

(3) *Crates.*—These are used for crating bombs, projectiles, components, and metal powder containers to give added strength and protection, and where packing in a closed box is not necessary. Metal crates, of steel, are used entirely in the shipment of some bombs. Other crates are wooden.

(4) *Cartridge storage cases.*—These are made of fiber or metal, are cylindrical, moistureproof, airtight, and are used for packing propelling charges for separate loading ammunition.

(5) *Fiber containers.*—A slip-cover fiber container of the mailing tube type is used for the packing of complete rounds, of separate loading propelling charges for artillery weapons, of hand grenades, of assemblies of boosters and fuzes, of fuzes, etc. These fiber containers are usually shipped in bundles of three, by means of two cup-shaped cloverleaf-design metal end-covers. An automatic U-shaped packing stop is used in fiber containers for fuzed projectiles.

(6) *Miscellaneous.*—(*a*) Metal cans, of terneplate or tin plate, are used for packing small components of ammunition individually or in small quantities, to preserve them against moisture. Metal liners for wooden boxes are also used in many types of packing of components, in certain cases for small caliber complete rounds where a moistureproof container is desired, or for shipments of smokeless powder. Zinc-lined wooden boxes are used for storage of all cannon powders having a web less than .019 and compositions other than the nitrocellulose type.

(*b*) All-steel boxes of Navy design are used for storing all cannon powders having a web of .019 and greater. Sheet steel cylindrical drums are used for black powder, which is contained in a cloth bag inside the drum. The drums are crated for overseas shipments.

(*c*) Fiber cartons are used for packing primers or small fuzes, a small number being packed in each carton. Where it is desired to render the carton moistureproof, it is usually immersed in hot paraffin.

135. Regulations.—*a.* The general regulations governing the packing, marking, and shipping of military supplies are set forth in AR 30-955.

b. Explosives and other dangerous articles offered for shipment on a common carrier will be packed to comply with Interstate Commerce Commission regulations, but paragraph 14 (a), section I, of these regulations states that "shipments of explosives offered by or consigned to the War and Navy Departments of the United States Government must be packed, including limitations of weight, in accordance with these regulations or as required by their regulations." Any proposed departure from the requirements of Interstate Commerce Commission regulations must be submitted to the Chief of Ordnance for decision.

c. Military explosives and ammunition are packed in accordance with U. S. Army specifications and drawings. The methods of packing specified and used not only meet military requirements and protect the articles from damage in transit but are also designed to comply with Interstate Commerce Commission regulations.

d. When shipments of explosives and other dangerous articles are to be made and containers are not available which comply with U. S. Army specifications for the particular article to be shipped, containers complying with Interstate Commerce Commission regulations will be used. This applies particularly to the shipment of deteriorated explosives or ammunition and to powder, explosives, and loaded components of ammunition obtained from salvage operations.

e. Other sources of regulations concerning packing will be found in the various Technical Manuals and Regulations, Standard Nomenclature Lists, Ordnance Field Service Bulletins of Series 3, Ordnance Safety Manual O. O. 7224, AR 30-1270 (shipments by water), and U. S. Army specification 49.0-7 (general packing specifications).

136. Sealing.—Packings are sealed for airtightness by closing the test hole of airtight cartons, containers, or cases with solder or a plug. Each container, after the contents are properly packed, is sealed in some manner which will indicate whether or not the container has been tampered with. The method of sealing depends upon the type and construction of the container. Where metal strapping is used around boxes, paper seals are not necessary and will not be used in the future.

137. Marking.—*a. On ammunition items.*—(1) As few markings as possible for positive identification are used on ammunition and its components. Such items as caliber and type, model or mark number, zone marking, lot number, year of loading, and initials or symbols of loading plant are stenciled on ammunition and its components. Colors

are used to indicate the type of ammunition. In general, two systems of color markings are employed, one for small-arms ammunition and the other for all other types of ammunition, including artillery and mortar ammunition, bombs, grenades, mines, and pyrotechnics.

(2) Armor-piercing cartridges are identified by the blackened point of the bullet. Tracer cartridges are identified by the colored lacquer or stain on the point of the bullet. Otherwise, small-arms ammunition is distinguished by the colored bands marked on the packing boxes which are listed in paragraph 57.

(3) (*a*) Whereas small-arms ammunition is not marked by painting, except in tracer and armor-piercing cartridge type, all other ammunition is painted or indicated as to the type of filler according to the basic color scheme.

(*b*) Igniters for propelling charges and primer-detonators for bombs are located by a red mark on the packing.

(*c*) In complete rounds in which two alternative complete propelling charges are provided, the propelling charge bag for inner zones is dyed green; that for outer zones is white.

(4) For other markings on ammunition, see previous sections of this manual and other Technical Manuals on ammunition.

b. On containers.—(1) AR 30-955 contains general regulations governing the marking and shipping of military supplies. AR 30-1270 contains regulations on packages to be shipped by water and also a list of shipping names; a compilation of such a list of shipping names will be found in OFSB 3-12. U. S. Specification 100-2 also contains regulations for marking containers.

(2) With certain exceptions given in AR 30-955, each package of supplies turned over for shipment on a Government bill of lading is marked with—

(*a*) Name and address of consignee.
(*b*) List and description of contents.
(*c*) Gross weight in pounds, displacement in cubic feet.
(*d*) The number of the package.
(*e*) The letters "U. S. W. D." in several conspicuous places.
(*f*) Order number, contract number, or shipping number.
(*g*) Ordnance insignium and escutcheon.
(*h*) Name or designation of consignor preceded by word "From."
(*i*) Lot number.
(*j*) Month and year packed.
(*k*) Inspector's stamp.

(3) Markings on boxes, barrels, or crates are made in stencil black or stencil white, whichever is more appropriate. In case of small-arms ammunition, where the box is painted brown, the marking is in yellow.

When it is impractical to stencil or paint the markings on the containers, or whenever a container is not used in shipping, at least two shipping tags bearing markings should be used. The shipping tags may be of cloth, leather, metal, or waterproof paper, the tags being attached to the article by wire. The use of writing ink, chalk, or marking material other than waterproof ink or paint is prohibited.

(4) The use of certain conspicuous and distinctive labels is required by the regulations for containers. They are furnished, on requisition, by The Quartermaster General and must be attached before delivery to the carrier.

(5) Often the color distinguishing a particular kind of ammunition is also indicated on the box or container. Boxes or containers for green bag propelling charge, white bag propelling charge, or section of propelling charge containing the black powder igniter, are painted with green, white, and red stripes, respectively. Boxes for bombs are painted with stripes around the center and on each end according to the color scheme in paragraph 8. The adhesive sealing strip on fiber containers containing complete rounds of low explosive mortar ammunition or shrapnel is colored red to indicate the presence of black powder; that on containers of HE shell is yellow.

(6) Before issue of small-arms ammunition, it must be identified by type and lot number from the labels of the original packages. Colored bands, painted on the sides and ends of the packing boxes, identify the various types of small-arms ammunition. The color bands used are listed in paragraph 57.

138. Lot number.—*a.* An important part of the marking for military explosives and ammunition is the lot number. The lot number will always appear on the containers and data cards and whenever possible on the ammunition itself.

b. Lot numbers consist of letters and figures which represent the initials of the manufacturer or loading company, the number of the War Department procurement order, the serial number of the lot, and in some case the date. Variations from this general scheme will be noted, since it is not practicable to use the same system of lot numbering for all kinds of explosives and ammunition.

c. The identification of military explosives and ammunition by lot number is essential for surveillance. It is the means by which stocks are conserved or utilized to the best advantage, and defective or deteriorated ammunition is withdrawn from service. It is also used in selecting ammunition for issue, because the ballistics or performance of ammunition when fired may vary from lot to lot. See discussion of lot numbers in paragraph 7.

139. Data card.—The data card gives all the necessary information for proper and complete identification of the item or component. Data cards are prescribed for use with all items of ammunition containing explosives, except explosives in bulk. They are usually required by specifications for nonexplosive materials procured for use with ammunition. The 5- by 8-inch data card is placed in every box (two in metal-lined boxes, one inside and one outside the liner) and one attached to every crate or large item inclosed in a crate. Externally attached cards, which might be exposed to the weather, are inclosed in a waterproof envelope. Ammunition data cards are prepared in quadruplicate for each lot of loaded projectiles. The preparation and distribution of ammunition data cards will be found in OFSB 3-2. In the case of separate loading propelling charges, a linen tag containing similar data is attached to the charge in lieu of a data card.

SECTION V

SHIPPING

140. General.—This section contains special regulations for the shipping and transportation of explosives and ammunition. The general regulations are contained in AR 30-955.

141. Regulations and references on transportation.—*a. Compliance with laws and regulations.*—Shipments of explosives and ammunition made by Military Establishments will comply with Interstate Commerce Commission regulations, port and harbor regulations, State and municipal laws, and Bureau of Explosives recommendations. Difficulties encountered in complying with the above will be reported in detail, through channels, to the Chief of Ordnance.

b. Interstate Commerce Commission regulations.—(1) The transportation of explosives and other dangerous articles within the limits of the jurisdiction of the United States is regulated by Federal law, act of March 4, 1909, chapter 321, sections 232 and 234 (35 S. 1134), as amended by the act of March 4, 1921, chapter 172 (41 S. 1444-1445), and the Dangerous Cargo Act of October 9, 1940 (Public No. 809, 76th Cong.).

(2) Section 233 of the above-mentioned act reads as follows:

The Interstate Commerce Commission shall formulate regulations for the safe transportation, within the limits of the jurisdiction of the United States, of explosives and other dangerous articles, * * * which shall be binding upon all common carriers engaged in interstate or foreign commerce which transport explosives or other dangerous articles by land or water, and upon all shippers making shipments of explosives or other dangerous articles via any common carrier engaged in interstate or foreign commerce by land or water.

(3) Section 235 of the act of March 4, 1921, requires the shipper of explosives and other dangerous articles to describe, pack, and mark his packages properly, and to inform the agent of the carrier in advance of the true nature of their contents.

(4) Section 232 of the act of March 4, 1921, provides that it shall be unlawful to transport certain explosives on any car or vehicle of any description operated in the transportation of passengers by a common carrier engaged in interstate or foreign commerce, which car or vehicle is carrying passengers for hire.

(5) The Interstate Commerce Commission Tariffs No. 3 and No. 4 contain the regulations for the transportation of explosives and other dangerous articles by water on freight and freight-and-passenger vessels and by land on freight, express, and baggage rail services, respectively. They are also known as Agent W. S. Topping's Freight Tariffs Nos. 3 and 4. Supplements and reissues are published from time to time. The regulations governing the transportation of explosives and other dangerous articles by motor vehicle on highways are published in Interstate Commerce Commission Motor Carrier Safety Regulations, Revised, Part 7.

c. Bureau of Explosives.—Section 1, paragraph 5, of the Interstate Commerce Commission regulations covering shipments of explosives and other dangerous articles by rail, reads as follows:

> The service of the bureau for the safe transportation of explosives and other dangerous articles, hereinafter called Bureau of Explosives, will be utilized by this commission in the execution of these regulations. This bureau will make inspections and conduct investigations, and will confer with manufacturers and shippers with a view to determining what regulations will within reasonable limits afford the highest degree of safety in packing and preparing these dangerous articles for shipment and in transporting the same. The commission will avail itself of the expert knowledge thus developed, and in formulating amendments to these regulations, while not bound thereby, will give due weight to the expert opinions thus obtained.

The Bureau of Explosives was organized in 1906 by the American Railway Association. Nearly all common carriers are members of the American Railway Association and comply with the rules and regulations issued by the Bureau of Explosives. Inspectors of the Bureau of Explosives are stationed throughout the country to observe, investigate, and report upon shipping methods, and common

carriers utilize the services of the inspectors of the Bureau of Explosives to enforce regulations, to approve methods and practices, and to assist shippers. The name and address of the nearest Bureau of Explosives inspector can be obtained from the local railroad agent, or by writing to the Bureau of Explosives, 30 Vesey Street, New York City.

d. State and municipal laws, ordinances, and regulations.—In addition to the Federal laws governing interstate transportation of explosives and other dangerous articles, each State and nearly all municipalities have laws or ordinances regulating the transportation of explosives and other dangerous articles within their jurisdiction. The harbor regulations of the port of New York or port of Baltimore and city ordinances requiring motortrucks or wagons carrying explosives to display a red flag of placard are examples of such State and municipal laws and ordinances.

142. Rail shipments.—*a.* The Interstate Commerce Commission regulations which govern the transportation of explosives and other dangerous articles by rail are essentially safety regulations and describe in detail how such shipments will be handled, loaded, braced, and stayed, and placarded. (See also AR 30-955.) Bureau of Explosives Pamphlet No. 6 contains data, photographs, and drawings of recommended methods of bracing and staying shipments. These recommendations, although for commercial explosives and other dangerous articles, can be readily adapted to military explosives and ammunition, and will be followed when a method such as that set forth in U. S. Army Specification No. 50-21-4 is not prescribed. See figure 65 for a method of packing projectiles in freight cars.

b. When making shipments of explosives and ammunition by rail, Bureau of Explosives pamphlets should be consulted for ideas as to piling and packing, and Interstate Commerce Commission regulations for information as to legal requirements. The cargo should be studied and decision made beforehand how it may best be stowed. The car best suited for the needs at hand should be ordered. When the car arrives, it should be given a thorough sweeping and inspected for protruding nails and bolt heads, which must be removed or covered with wood. The sides of the car should be boarded up where necessary to obtain an even bearing and proper dunnage (see Bureau of Explosives pamphlets). Substantial gangways should be provided; obstructions which may prevent free entry to the car removed; the immediate vicinity cleared of leaves, dry grass, and other inflammable materials; and the brakes set and wheels chocked. During loading operations, the car and magazine doors should be closed when engines or speeders are passing. Cars should not be left partly loaded, unless impossible to finish loading at one time, in which case car doors must be securely locked. After loading, the shipment should be properly braced and stayed, the car properly sealed and placarded, and a permanent record of car numbers kept. In unloading cars the same safety precautions that have been outlined above should be observed. All cars that have contained explosives should be carefully swept and all placards removed. Sweepings should be thrown in running water, burned, or placed in a metal receptacle for later disposition. All shipments received in a badly damaged condition should be reported through channels to the Chief of Ordnance.

c. Interstate Commerce Commission regulations require the use of a "certified car" for shipment of explosives. A "car certificate" must be signed in triplicate by a representative of the carrier and of the shipper after the shipment is loaded and properly braced. Two of these must be attached outside of the car doors or to the sides of the car, one on each side, in addition to any explosives placards.

d. Dangerous explosives must not be transported in any self-propelled car operated by electric or other motive power if such car is carrying passengers.

e. Loaded railroad cars will not be left in the open area between magazines, as they may act as an intermediate step in propagating an explosion.

143. Water shipments.—*a.* Interstate Commerce Commission Freight Tariff No. 8 prescribes regulations for the transportation of explosives and other dangerous articles by water on freight and freight-and-passenger vessels. Other regulations that apply are port and harbor regulations of the various cities and States affected and regulations of the carrier, usually the Quartermaster Corps or the Navy Department.

b. When shipments of explosives and ammunition are made by water, the local port regulations regarding the handling of explosives should be studied and the regulations for tonnage, lights, open fires, stoves, mixed loads, flags, anchors, etc., complied with. When equipment for shipments is chartered, the equipment should be passed upon by port authorities before it is accepted for use. During loading, the safety regulations for open fires, stoves, gasoline, matches, smoking, etc., will be strictly complied with; decks, runways, and docks should be free from dirt, rubbish, and spilled explosives; and personnel should handle explosives and ammunition with care so as to avoid danger and damage to the shipment. If the loading is not completed during the day, proper precautions will be taken to guard and protect the shipment against fire and a sufficient crew will be left in charge to

handle the boat in case of emergency. Explosives or ammunition should not be left on a dock or elsewhere unless delivery is made to authorized persons or explosives left under proper guard. Explosives and ammunition must not be left on board boats overnight unless such action is imperative incident to their transportation. Lighters should not be tied up to that part of a vessel or dock where the fireroom or boiler is located. Explosives should be kept as far away from engine and boiler room as possible.

c. The use of oil- or chemical-burning lamps or lanterns is prohibited in the neighborhood of explosives. Only electric lanterns will be used when a movable artificial light is necessary. In port and starboard lights and other such necessary signals, oil-burning lights are permitted; these should be placed, removed, and filled by a responsible officer, who should see that they are not brought in contact with explosives or do not introduce fire risk to the boat or barge. Storage of paints, oils, varnishes, or other inflammables is prohibited on any boat or barge used for explosives or ammunition. Such oil as is necessary in connection with the machinery of a boat must be kept under the direct charge of the chief engineer, and only a day-to-day stock permitted. Oils used for signal lights and in living quarters must be kept under lock and key, and should be in direct charge of the officer in charge of the lights. Oil must not be put in or removed from this compartment at night. If oil accidently gets on the floor, it must be immediately swept up with sawdust and the sweepings thrown overboard.

d. No explosive will be placed on board any vessel until all the other cargo has been placed aboard. As far as is practicable, the necessary work in the construction of floors, magazines, partitions, etc., or for the removal of any combustibles from that part of the hold in which explosives are to be stowed, should be completed before loading of the explosives is commenced. All rubbish, shovelings, old oil, paint cans, oily rags, rope ends, etc., must be cleared out of the hold. Floors must be kept broom clean. All decks, gangways, and holds over which explosives must be passed in loading must be freed from all loose metals or tools, and carefully swept before loading is commenced and after loading has ceased.

e. The hatches of the vessel will be kept closed except during the loading and unloading of the vessel, and when so closed will be covered with tarpaulin battened.

f. Lighters, barges, scows, and all tugs engaged in hauling vessels loaded with explosives must have their funnels or smoke stacks covered with screening of suitable size to prevent the exhaust of sparks and this screening must be renewed whenever it is broken.

g. Magazines (cargo space) for explosives must be lined entirely with wood not less than 1 inch thick, nailed with cement-coated nails with heads countersunk. Metal obstructions or constructions within the area of the magazine must be entirely covered with wood, nailed as mentioned above.

h. Explosives awaiting removal or delivery must be stored outside the dock or wharf when practicable and every possible effort must be made to reduce the time of this storage. Explosives held for delivery or loading must be in a safe place, and away from other dangerous articles.

i. All packages of explosives must be handled carefully. They must not be thrown, dropped, or unnecessarily dragged, rolled over each other or over decks. Portions of metal decks or exposed metal objects and surfaces must be covered with wood, canvas, or other material that will tend to prevent the occurrence of sparks. When explosives cannot be transferred by hand or chute, transfer must be made by mechanical hoists and special crate or basket. If slings are needed, those entirely of rope will be used. Packages containing explosives must be so stowed and stayed in the lockers, compartments, or magazines of vessels that they will not shift in any direction. Broken or seriously damaged packages will not be accepted for transportation. Repacking will not be done on or near any vessel, barge, lighter, or scow having explosives on board. Any explosive that has escaped from a broken or otherwise defective package will be immediately swept up and removed to a safe place.

j. Transportation of explosives, except small-arms ammunition, on ships carrying passengers is prohibited.

144. Motor truck shipments.—*a.* Transportation of explosives and other dangerous articles by truck is covered by chapter 7, Interstate Commerce Commission Motor Carrier Regulations. Such of these regulations as are applicable will be complied with. Nearly all states, cities, towns, and villages also have laws governing the transportation of explosives and other dangerous articles within their jurisdiction. When making shipments of explosives and ammunition by motor, local civil authorities of the cities and towns through which the explosives and ammunition are to be transported should be consulted and their rules and regulations for the transportation of explosives and ammunition strictly observed. Their recommendations as to the best route to follow should be obtained so as to avoid congested areas. If compliance with these laws is manifestly impractical, then the matter will be referred to the Chief of Ordnance for decision.

b. Except in cases of emergency, no explosive materials or ammunition containing explosive elements, except small-arms ammunition,

will be shipped by motor truck without prior approval of the War Department. The intention is to avoid shipping by truck all types of explosives and ammunition, except small-arms ammunition, where rail or water transportation is available. However, this regulation does not apply to local or nearby hauling, delivery, or movement.

c. Explosives and other dangerous articles will not be shipped by any commercial highway carrier, nor will local drayage thereof by any commercial concerns be engaged, unless the carrier or drayage concern files a certificate with the quartermaster arranging for such service that said carrier or drayage concern will comply with all laws and regulations promulgated by Federal, State, and local governments and municipalities that may be applicable to and govern each particular shipment of explosives and other dangerous articles.

d. If shipments of explosives, toxic gases, and other dangerous articles are made by United States Government operated motor vehicles, the shipping officer will take all necessary and reasonable precautions to insure its safe transit. Except in time of emergency, the shipping officer will be responsible that all Interstate Commerce Commission regulations governing the transportation of explosives are observed. In case of emergency, so declared by any commanding officer of an arsenal or depot, or a general or field officer of the line, the shipping officer will take every reasonable precaution to insure safe movement of his cargo of explosives, toxic gases, or other dangerous articles while in transit by motor vehicle on Government reservations and on the public highways.

e. Every precaution against fire should be observed. Trucks should be inspected daily to see that electric wiring, lights, brakes, gasoline tanks, and lines are in good working order; the engine clean of dust and oil, and the engine pan free from accumulations of dirt and grease. The splash of oil or grease from the universal joint, transmission, or other moving parts onto the under side of footboards or body of the car should be cleaned thoroughly after each long trip or day's work. Leaking gasoline tanks or lines should be repaired immediately, and lighted cigarettes, pipes, and open lights kept away from the vicinity when filling gasoline tanks. Where necessary, safety matches may be used. They may be kept in a metal container in the tool box. Use of strike-anywhere matches is prohibited. The amount of waste in the truck should be kept to a minimum, and oily and clean waste separated. Trash should not be permitted to accumulate in the tool box. All trucks will be provided with at least one properly filled fire extinguisher. All drivers and other employees should be instructed as to the best method of extinguishing gasoline fires with Pyrene and should be impressed with the fact that in nearly all cases there is time to extinguish a fire, as it takes an appreciable time to heat ammunition to the point where it will explode.

f. When explosives and ammunition are being transported by a convoy of trucks, the trucks should not become widely separated but a safe distance should be maintained between them so as to avoid danger of collision. The convoy should be stopped once each hour during the trip to inspect each truckload. Stops should not be made within or close to the limits of cities, towns, or municipalities, and in driving through towns and cities congested streets should be avoided as much as possible. A moderate speed should be maintained and the truck kept under control. A full stop is required at railroad crossings. No unauthorized person will be permitted to ride on trucks. If a truck catches fire, the other trucks will proceed to a safe distance (out of the zone of danger in case of an explosion) and guards will be posted at a distance of several hundred yards on each side of the truck to stop all traffic. If a truck breaks down and it cannot be towed to its destination by one of the other trucks, a guard of two men should be posted and the post to which the convoy is proceeding should be notified so that a truck can be dispatched at once with loading personnel to relieve the disabled truck of its load.

g. Fuzes or other detonating agents should not be transported with other explosives, except ammunition for cannon shipped with fuzes or boosters assembled. The load should be well braced and stayed and tarpaulins available to protect the load from the weather or from sparks from passing locomotives, etc. Explosives and ammunition should not be unloaded or piled immediately back of the exhaust. This regulation is intended to apply to bulk shipments of ammunition by motor truck and is not intended to prohibit the carrying of complete rounds of artillery ammunition, including fuzes and primers, in one vehicle by combat units. No regulations will be construed to prohibit the carrying of complete rounds of artillery ammunition, including fuzes and primers, in one vehicle by combat units.

h. When transporting artillery ammunition, all projectiles should be laid on the side instead of on the base and with the sides of the projectiles parallel to the side of the truck so that the projectiles will not roll back against the tail gate of the truck and damage it. If it is necessary to place more than one layer of projectiles in the truck, strips of planking should be placed over the first layer of projectiles to protect the rotating bands from becoming deformed through contact with other projectiles when the truck is in motion.

i. No container of explosive or other dangerous article may be accepted for transportation by a motor carrier if it is in a leaking condition, or in such a condition as to make leakage possible, except as prescribed in Interstate Commerce Commission Motor Carrier Safety Regulations, Revised, Part 7. These motor vehicle regulations are subject to further limitation with respect to transportation by water, especially of leaking containers. Any package of explosives found injured or broken in transit may be repaired when this is evidently practicable and not dangerous, and must be done in accordance with the best and safest practice known or available, and at least 100 feet distant from other explosives or ammunition. When a box containing any explosive is so damaged that it cannot be repaired, it should be reinforced by stout wrapping paper and twine, placed in another strong box, and surrounded by dry fine sawdust, or dry and clean cotton waste, or elastic wads made from dry newspapers. The box cover should then be securely attached. When any package is found to be leaking or damaged and cannot be recoopered, it may not be transported beyond the minimum distance necessary to reach a place where the explosive may be disposed of with safety.

j. The proper signals, reflections, and portable lights and reflectors must be carried by motor vehicles. All fuel tank inlets shall be equipped with a device to relieve internal pressure. Exhaust pipes will be protected by a properly constructed flame baffle. The floors of all vehicles must be tight and exposed metal on the body covered or protected with wood or other nonmetallic material. Motor trucks containing explosives will never be taken into a garage or repair shop for repairs or storage unless it is an open, sunshade garage where no open-flame lighter or burner is in use. Explosives, when possible, will be transported during daylight. When artificial lights are necessary, only approved electric lights or electric lanterns may be used.

k. Before any explosive is loaded into or unloaded from any motor vehicle, the engine of the vehicle must be stopped and the brakes set. For any continuous trip longer than 8 hours, the driver must be accompanied by an assistant. Every shipment of dangerous explosive will be delivered only to a person authorized to receive it, except such shipments as are placed in magazines which are immediately thereafter locked.

l. Loaded trucks will not be left in the open area between magazines, as they may act as an intermediate step in propagating an explosion.

m. Prescribed markings on motor vehicles carrying explosives or ammunition will be by means of signs or lettering on each side and the rear of the motor vehicle in letters at least 3 inches high on a background of sharply contrasting color.

n. Refuelings should be reduced to a minimum. The electric ignition system should be turned off and the engine stopped during the

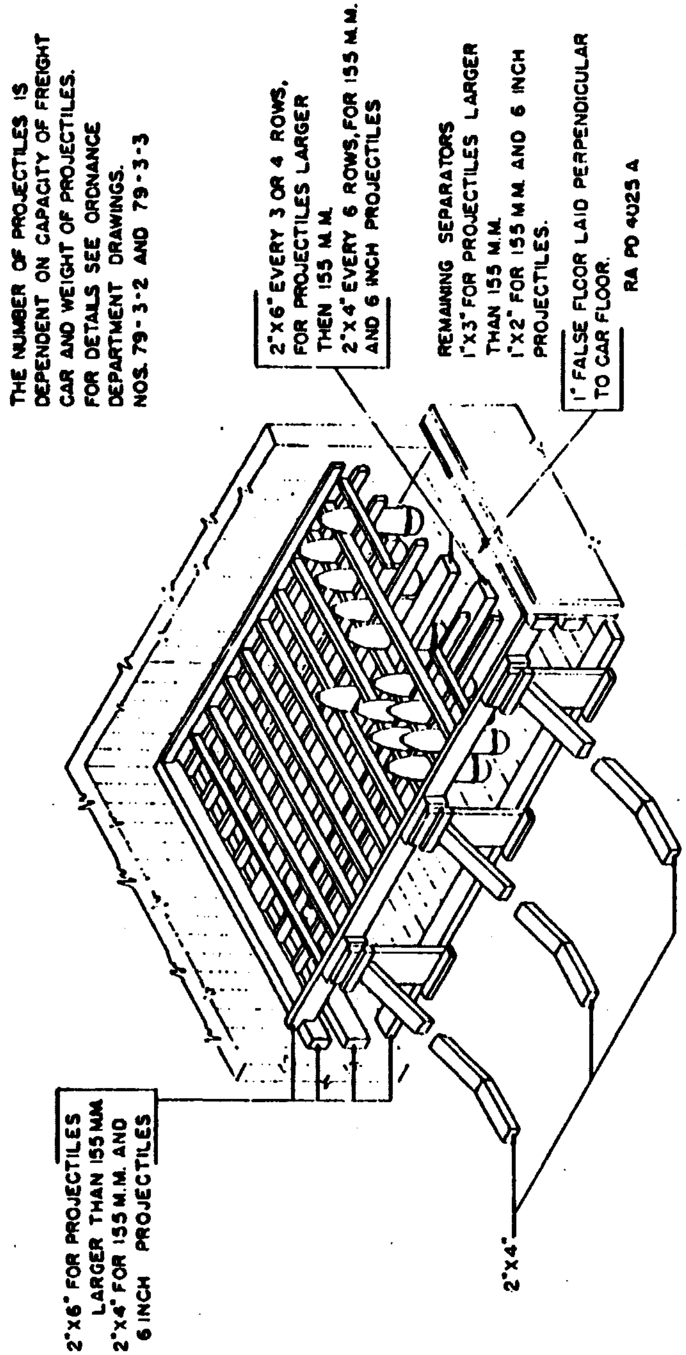


FIGURE 65.—Method of stowing shell in freight car.

refueling process. If the engine is provided with a magneto, it should be grounded.

o. Every motor vehicle will have pneumatic tires.

p. In case of accident, all unbroken packages and as much of any broken packages as possible will be carefully gathered and removed to a place of safety in order to prevent fire or explosion. Care should be taken not to produce sparks. In the event that a motor vehicle is entangled with another or with an object or structure, no attempt will be made to disentangle the same, until the load is removed to a place 200 feet from the vehicle or any habitation. Inhabitants and other vehicles will be warned of danger.

SECTION VI

PRECAUTIONS FOR PRACTICE FIRING

145. General.—Specifications, standards, and limits of precision are prescribed for the manufacture and preparation of ammunition. In spite of this, inherent limitations exist and malfunctions of ammunition may occur. The immediate problem is to prevent the occurrence of malfunctions wherever possible, to minimize the effect when they do occur, and to profit by such experience by avoiding the same or similar malfunctions in the future. The general safety precautions, section I, should be observed wherever applicable. The regulations and precautions given in chapter 2 for the use of each type of ammunition will be observed.

146. General precautions before firing.—*a. Status of ammunition lots.*—A check should be made to determine the status of the lot of ammunition which it is intended to issue. Ammunition should not be fired if the lot number is not positively known. If defects which may affect the safety and functioning of the ammunition are found in a lot which is graded as being suitable for firing, a prompt report of the condition will be submitted to the corps area or department ordnance officer. Firing of that lot of ammunition will be suspended pending instructions from the proper ordnance officer. If malfunctioning of the lot of ammunition occurs during firing, a prompt report will be made as prescribed in AR 45-30 and the firing of that lot will be suspended pending directions from the office of the Chief of Ordnance.

b. Alterations and substitutions.—Any alteration of loaded ammunition, except in accordance with specific instructions from the Chief of Ordnance, is hazardous and is therefore prohibited. Serious and fatal accidents have resulted from substitution of propelling charges, fuzes, primers, and projectiles and from the local preparation and loading of practice ammunition, including grenades, pyrotechnics, etc.

c. Placing ammunition.—All ammunition at the firing point will be so placed as to minimize the possibility of ignition, explosion, or detonation in case of accident at the gun position. It should be in a dry place and protected from the direct rays of the sun by tarpaulin or other covering. There should be ample circulation of air through and on all sides of the pile. Erratic ranges and dangerously high pressures may result because of overheated ammunition. White phosphorus shell will be piled away from personnel shelter and other ammunition in a space cleared of all combustible material. All components in the field should be stored separately and in small amounts so as to minimize danger from accidental burning of powder or detonation of projectiles, fuzes, and primers. Chemical ammunition is stored away from other types of ammunition.

d. Safety zones.—Data for delimiting safety zones for ranges in firing small arms, artillery weapons, and chemical warfare weapons will be found in AR 750-10.

e. Smoking.—Smoking by anyone handling, or in the vicinity of, explosives or ammunition is prohibited.

f. Lights.—Use of any lights, other than approved lanterns or flashlights, in the vicinity of explosives or ammunition is prohibited.

g. Handling.—Care should be taken not to drop projectiles, powder containers, or fuze or primer boxes. Projectiles should not be allowed to strike together. All safety precautions in handling ammunition given by Technical Manuals and regulations and other sections of this manual will be rigidly observed.

h. Packings.—Moisture-resistant seals of packed ammunition should not be broken until the ammunition is ready to be used. Rounds should not be withdrawn from containers until they are ready to be fired, unless the ammunition is to be loaded directly into the caisson. Fuze covers on powder time train fuzes and safety devices on fuzes will be removed just before firing and at no other time. Components of rounds prepared for firing but not fired will be returned to their original packings and appropriately marked and resealed. Such

components will be used first in subsequent firings, in order that stocks of opened packings may be kept at a minimum.

i. Cleanliness.—The complete round or each component should be inspected by a member of the gun crew for burs, dents, gravel, dirt, grease, etc., before loading into the gun. A cloth should be kept handy for wiping off grease, dirt, and foreign matter. Ammunition must be clean and free from dents before it is placed in the breech of the gun.

147. General precautions during and after firing.—*a. Defects and malfunctionings.*—AR 45-30 provides that all officers having charge of firing must make a report to the local ordnance officer of any ordnance matériel issued to the troops which malfunctions in firing or reveals defects either in firing or in storage, including such malfunctions and defects as are noted in target practice reports. It is the duty of the local ordnance officer to investigate all cases of malfunctioning and defects observed by him or reported to him and to report serious cases to the Chief of Ordnance through the corps area ordnance officer. Whenever an accident occurs which results in injury to personnel or damage to matériel, the lot of ammunition will be suspended from use and an immediate report will be made directly to the Chief of Ordnance by the ordnance officer under whose supervision the matériel is maintained or issued. One copy of this report will be sent to the corps area ordnance officer. Accidents of a serious or potentially serious nature require reporting by the quickest means of communication available. Until the arrival of an investigating officer, all evidence will be carefully preserved and, insofar as is practicable, will be left undisturbed.

b. Protection to personnel.—Whenever high explosive ammunition is fired, proper precautions will be taken to insure protection of all personnel against premature burst, as prescribed in AR 45-30. AR 750-10 gives the regulations and details for protection of persons in the vicinity of the firing point. Any individual in the military service who observes a condition which makes firing obviously unsafe will immediately give the command CEASE FIRING. If at a distance from the unit firing, he will make the prescribed signal therefor. No lethal or toxic gas will be used for training purposes in time of peace. When chemical ammunition other than smoke is fired, all persons will be provided with gas masks. The firing of shell and shrapnel over the heads of unprotected personnel in time of peace is prohibited.

c. Firing through trees.—When firing ammunition from a mask of trees, a premature burst may result if a fired shell or shrapnel strikes the branch of a tree. The striking of even a twig by a shell fitted with a time fuze may result in a derangement of the setting or deformation of a time ring sufficient to cause a premature burst.

d. Duds.—A dud is a discharged but unexploded bomb, projectile, or grenade. It may result from defects in the fuze, booster, or charge; the unscrewing of fuzes in flight; or the character of the ground at the point of impact. Whenever a dud can be readily located and examined without moving it, an effort should be made to determine the cause of the failure. A dud in itself is a source of danger, and if improperly handled may result in an explosion with injuries to personnel. A comparatively slight blow or turning of the dud may cause it to explode at any time. Duds should be destroyed in place: for methods of destroying see chapter 4.

148. Small-arms ammunition.—*a.* Before issuing small-arms ammunition of any type, it will be examined. The procedure for examination and the defects to look for will be found in TM 9-1990. OFSB 3-5 contains essential information concerning the grading of small-arms ammunition and the disposition of fired components and unserviceable small-arms ammunition. Lots having more than 5 percent of defective cartridges will be subjected to 100 percent inspection, defective rounds culled out, the serviceable cartridges repacked prior to issue, and report made to the Chief of Ordnance. Normally, small-arms ammunition, unless it has been stored for a considerable period, will have no visual defects, and any ammunition having less than 5 percent visually defective rounds may be issued without 100 percent inspection. If 20 percent or more are defective, the lot is withdrawn from service and held for disposition. The post ordnance officer should see that the troops are instructed as to the kinds of visible defects which can be readily detected and the correct manner in which to cull ammunition. Particular attention should be paid to incipient cracks which are not easily detected unless the thumb is pressed against the bullet, thus exposing the crack in the cartridge case. Defective cartridges will be considered as grade 3 ammunition.

b. Since different types of small-arms ammunition are of similar appearance, this kind of ammunition will be strictly checked from the markings on the packing.

c. Blank cartridges should not be fired at a representative enemy at distances less than 20 yards, as the wad or paper cup may fail to break up.

d. (1) For procedure in the event of an apparent misfire see paragraph 56*a* and *b*.

(2) When a hangfire occurs in any lot, its use should be suspended and a report made to the post ordnance officer, giving the number of

the lot involved. The ammunition lot thus affected will be withdrawn and replaced by serviceable ammunition.

e. When a bullet lodges in the bore of a rifle, pistol, or machine gun, it should be removed by the application of pressure from the muzzle end of the weapon. *To attempt to shot the bullet out with another cartridge is dangerous and therefore prohibited.*

f. Dented cartridges, cartridges with loose bullets, or otherwise defective rounds should not be fired.

g. Misfires in which the primer explodes but fails to ignite the powder charge have proved dangerous in firing automatic arms with blank firing attachments. Some of the powder is blown into the bore and becomes lodged in the blank firing attachment. A series of such rounds will cause an accumulation of powder sufficient to cause serious damage when ignited by a normal cartridge. When misfires occur in excess of 5 percent in firing blank cartridges, the firing of that lot of ammunition will be suspended and reported to the Chief of Ordnance.

h. The use of armor-piercing cartridges is prohibited in demonstrations in which tanks take part. In using armor-piercing ammunition it is well to remember that the cores of bullets that fail to penetrate will rebound. The radius of rebound depends on several factors but may safely be taken at a maximum of 100 yards for caliber .30 and 200 yards for caliber .50, armor-piercing ammunition.

i. After a box of ammunition is opened and cartridges issued, each man should take care of his own ammunition. The primer should be protected from blows by sharp instruments, as such a blow might explode the cartridge.

j. The use of oil or grease on cartridges is prohibited. Such use causes the collection of injurious abrasives in automatic weapons and causes excessive and hazardous pressures on the bolt of the rifle when firing in nonautomatic rifles.

149. Artillery ammunition.—*a. Examination.*—Before firing, representative samples from each lot of ammunition should be examined for visible defects such as exudation, badly corroded fuzes, projectiles loose in cartridge cases, damaged rotating bands, excessive moisture and dampness, etc. If these defects are likely to cause difficulty when the fuze is set or the round is loaded into the gun, or there is any question as to the safety and functioning of the ammunition, it should not be used until it has been examined by the corps area ordnance officer or his assistants. Care should be used in condemning ammunition for use, as shell which are exuding slightly can be made serviceable as prescribed in Ordnance Field Service Bulletins, and many times fuzes which are only slightly corroded or discolored are serviceable and can be used.

b. Packings.—In removing fixed ammunition from boxes, the screws or wing nuts which hold the covers in place should be removed. If the ammunition is packed in individual tin or fiber containers, these containers should be opened by means of the tear strip provided, but the rounds should not be withdrawn from the container until it is to be fired, unless the ammunition is loaded directly into the caisson. Fuze covers on shrapnel should not be removed until the round is to be fired. All powder charges will be kept in their containers except the charge which is to be served to the piece for the next succeeding round.

c. Placing of ammunition.—Ammunition at the firing point which is not carried in caissons should not be located directly at the rear of the gun, but to the left of the caisson, and should be protected from moisture and dampness and the direct rays of the sun by a tarpaulin so placed that air can circulate through the pile.

d. Propelling charges.—(1) *Premature ignition.*—The powder charge for any given round will not be brought near the breech of the gun until the preceding round has been fired, the powder chamber carefully sponged with a wet sponge or cleared of any possible smoldering remains by use of the air projectors, and the face of the mushroom head wiped.

(2) *Flarebacks.*—When the breechblock is withdrawn, the gases remaining in the bore sometimes pass to the rear and ignite upon striking the air, regardless of the direction of the wind. Flames of varying length and intensity result. Precautions must be taken to prevent the flame from reaching a new propelling charge, as well as to prevent serious burns to the breech detail.

(3) *Blending.*—Propelling charges will be habitually fired as received. Blending will not be resorted to except in special cases where the necessity therefor has been approved by the Chief of Ordnance, who will furnish the necessary instructions.

(4) *Erratic and excessive pressures.*—Erratic pressures or ranges may be due to deteriorating propelling charges, improper ignition of the propelling charges, defective or loose rotating bands, and in the case of separate loading ammunition, to improper wrapping or lacing of the charge. Excessive pressures are likely to develop if the diameter of the propelling charge is altered so as to prevent the projection of the flame from the igniter to the front of the powder charge. For further information, see AR 750-10. All powder lots giving excess pressures should be immediately suspended from use pending instructions from the Chief of Ordnance. A sample of the powder involved should be sent to the nearest ordnance depot, together with a copy of the report of the malfunctioning and the record of the stability of the powder.

(5) *Maximum ranges.*—The caliber board report has purposely used

the term "supercharge" in referring to the propelling charge required to give maximum range. It cannot be too strongly emphasized that the normal charge should be used always within the ranges obtainable, and the use of supercharges must be avoided except where maximum ranges are necessary, otherwise excessive wear of the guns will result. With multisection propelling charges, when "supercharge" is desired the complete charge is used and when "normal charge" is desired the base section only is used.

(6) *Igniters.*—(*a*) In loading the separate loading propelling charge into the gun, care must be exercised that an igniter is always on the end of the charge toward the breech. The cloth used for making igniters is dyed red to indicate clearly the end which should be at the rear of the chamber. The red dye also indicates that the igniter contains black powder. Undyed igniter cloth has been used, however, for some propelling charges now in the service. In this case the igniter end can be identified by the quilting used to hold the black powder in position and the words IGNITING POWDER stenciled on the igniter.

(*b*) Propelling charges should not be placed in the gun with the igniter fastened thereto by safety pins. Before firing, the safety pins should be removed and the igniter pad attached to the charge by sewing, the stitching being caught in at least three places 120° apart.

(*c*) It is the practice to pack one igniter in each cartridge storage case. Surplus igniters remaining after firing should be destroyed in accordance with chapter 4.

(7) *Tags and protector caps.*—Igniter protector caps and data tags will be removed from the propelling charge before loading it into the gun.

e. Difficulties in loading or extracting ammunition.—Difficulties in loading or extracting ammunition may be due to dented or bulged cartridge cases or foreign material in the chamber or bore of the gun. Where the cartridge cases are hard to extract, an inspection of the chamber should be made to determine whether it is fouled, scored, or pitted. If it is fouled, it can be readily cleaned; but if it is pitted or scored, a report should be made to the post ordnance officer. If a projectile cannot be readily extracted from the gun or should a projectile become separated from the cartridge case when the breech is opened, it should be removed under the direct supervision of an officer, using a rammer which bears only on the projectile and provides for clearance around the fuze. Extreme care should be exercised to prevent any force from being applied against the fuze. The Edwards rammer, designated as rammer, unloading, M1, is provided for this purpose for use with 75-mm point-fuzed projectiles (fig. 66).

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f. Misfires.—When a misfire occurs, the following precautions will be observed:

(1) *Fixed or semifixed ammunition.*—At least three attempts will be made to fire. After the last attempt, the breech will not be opened before 2 minutes have elapsed.

(2) *Separate loading ammunition.*—(*a*) If the primer is heard to fire, the breech will not be opened before 10 minutes have elapsed.

(*b*) If the primer is not heard to fire, two more attempts to fire will be made. Then—

1. If the primer can be removed by a person standing clear of the path of recoil, after 2 minutes have elapsed, the primer may be removed and a new one inserted. If the second primer fails, 10 minutes should be allowed to pass and then the breech may be opened.

2. If the primer cannot be removed safely as described above, no attempt will be made to open the breech or replace the primer for 10 minutes.

Misfire primers should be handled carefully and disposed of quickly due to the chance of a primer hangfire. Further information will be found in AR 750-10 and the Technical Manuals and Field Manuals pertaining to the piece.

g. Fuzes.—(1) Extreme care must be taken in handling and in assembling fuzes to shell or bombs. All fuzes must be treated as delicate mechanisms. The forces in the gun which arm the fuze can be simulated by rolling or dropping, and a fuze so armed may be functioned by the impact of a blow or by dropping.

(2) In the assembly of fuzes into projectiles, inspection should be made of the fuze body and threads and also of the adapter and fuze cavity to insure that grit, grease, or other foreign material is not present. This is necessary to insure proper seating of the fuze and to avoid the use of any great force. Cleaning of the fuze cavity should be accomplished with a piece of cloth and a small stick which can be inserted into the cavity. Fuze hole plugs should not be removed except for inspection or when the fuze is about to be inserted.

(3) When ammunition or projectiles are issued fuzed, no attempt should be made to remove the fuzes therefrom.

(4) Fuzes will not be altered. Any attempt to alter or disassemble fuzes in the field is dangerous and is prohibited except under specific direction of the Chief of Ordnance. The only authorized assembling or disassembling operation is that of fitting the fuze to the projectile if the round was not issued fuzed, or unscrewing the fuze from the projectile if not fired.

(5) Every precaution should be taken to keep moisture away from powder train time fuzes.

(6) Time fuzes are always issued set "safe" and if not used after making a setting they should be reset to "safe" before storing.

(7) Each round to be loaded which contains a point-detonating fuze should be kept well out of the path of recoil of the gun until recoil of the previous round has taken place, in order to prevent a heavy blow from hitting the fuze.

(8) When checking the accuracy of fuze setting by cutting trial fuzes, no fuze should be cut more than twice.

150. Blank ammunition.—*a.* Only blank ammunition furnished by the Ordnance Department will be used. Blank ammunition is issued to the using arms in complete rounds only. Smoke-puffs or blank ammunition will not be improvised where it is not provided for the piece.

b. The complete round of blank ammunition if kept intact, handled with care, and protected from fire provides a comparatively safe assembly. However, the following precautions should be observed:

(1) Under no circumstances will rounds of blank ammunition be tampered with in the field.

(2) Blank ammunition should not be removed from the fiber container sooner than is necessary before firing. Remaining rounds should be kept well away from the gun.

(3) Identification of the ammunition before firing must be positive and no attempt should be made to use it in a gun other than that for which it is intended.

(4) Any round in which the chipboard closing cup is not firmly in place should not be fired and should be handled with care until disposed of as directed in chapter 4.

151. Pyrotechnics, grenades, and chemical ammunition.—*a.* Pyrotechnics and grenades should be located some distance either to the right or left, and never directly behind the firing points. Protective measures against grass fires should be provided and extreme care should be taken to prevent a grenade or piece of burning pyrotechnic material from dropping into boxes of ammunition. Pyrotechnics which have been unsealed should be disposed of as provided in OFSB 8-9.

b. Smoke-producing materials will not be released in time of peace within 300 yards of personnel, livestock, buildings, equipment, or other objects which may be damaged. Equipment contaminated with corrosive acids produced by liquid smokes will be washed with water as soon as possible, except when other methods of protection or cleaning methods are prescribed in the appropriate Technical Manuals.

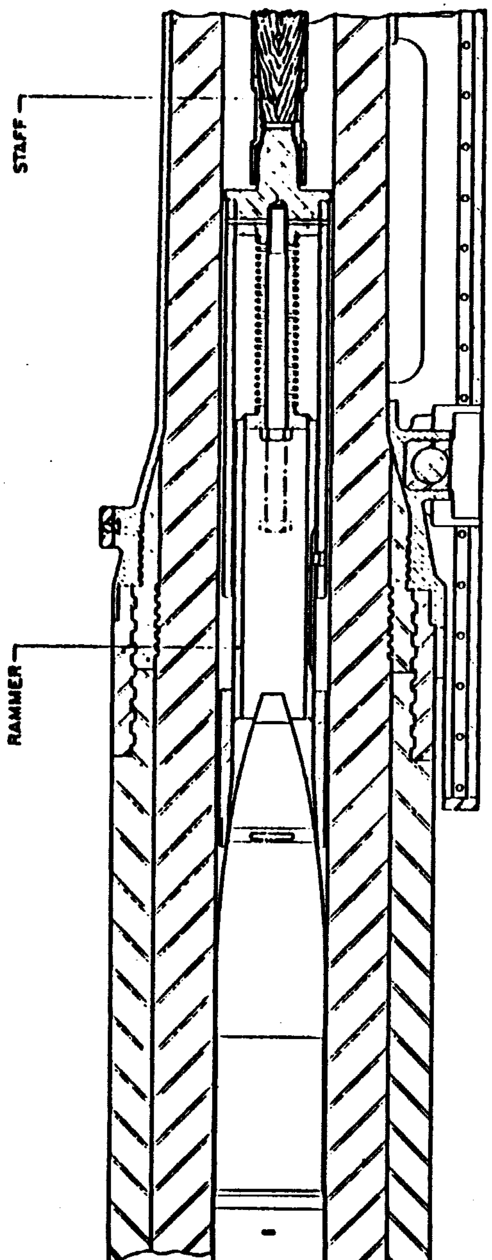

FIGURE 66.—Rammer M1 in use—method of removing shell from gun.

c. Burning type grenades, smoke pots, and two-compartment candles should be stored in a cool dry place. They should not be ignited within 5 feet of dry grass or other inflammable materials, if fire is to be avoided. Burning type grenades will not be fired closer than 20 feet from personnel, due to an occasional flashing grenade. In firing smoke pots, care should be taken not to have the face directly above the smoke pot when it is set on fire.

d. Unfuzed grenades will not be fuzed in ammunition dumps or storage magazines, nor in greater quantities than are needed for immediate use.

152. Bombs.—Procedure for precautions and repair of bombs in the field are given in OFSB 3-9. AR 750-10 prescribes precautions for the minimum altitude for functioning of bombs for aircraft in time of peace. Methods of unfuzing, disassembling, and handling bombs and safety precautions for the same are published in TM 9-1980. All live bombs will be carried safe and will not be armed until released.

153. Mortar ammunition.—The same safety precautions will be observed in the field in the handling and use of mortar ammunition as apply to artillery shell. Further information will be found in FM 23-85, FM 23-90, and TM 9-1935.

SECTION VII

AMMUNITION IN HARBOR DEFENSES

154. General.—*a. Moisture.*—In harbor defenses, the principal problem is keeping the ammunition dry. Attention will be given to ventilation of magazines and stacking of ammunition in boxes with adequate skids and dunnage to insure free circulation of air through the pile.

b. Blending.—Propelling charges will ordinarily be fired as received. Blending of propelling powder will be done only on specific instructions from the Chief of Ordnance.

c. Loading.—Loading and renovation of shell will be done in accordance with instructions and specifications prepared by the Chief of Ordnance.

d. Further information.—Refer to other sections of this chapter.

SECTION VIII

AMMUNITION AT SUPPLY POINTS

155. Supply points and distributing points.—*a. General.*—The details concerning ammunition supply points and distributing points, as discussed in this manual, are particularly applicable to those installations in the zone of the interior and at posts, camps, and stations. A complete discussion of the subject for application to the theater of operations (the communication zone and the combat zone) is contained in FM 9-6.

b. Location.—Supply points and distributing points should be located in the best available network of roads and near a railroad. Ammunition and explosives will be so located as to comply with the provisions of paragraph 116, with regard to quantity-distance requirements.

c. Lay-out.—In planning the lay-out of ammunition supply points and distributing points, consideration should be given to the following:

(1) *Amounts and kinds required.*—It is desirable that a field unit supply train be able to take on its complete load from stacks in a straight line or in a single area without having to enter and congest another area of the supply point.

(2) *Ease of access.*—They should be on good roads, near, but not on, main highways. Conspicuous signs should be posted on roads leading in, and military police should be notified of names and locations of dumps within their areas.

(3) *Traffic control.*—Roads should preferably be laid out in complete loops instead of turn-arounds. This has an additional advantage in that it provides access to piles from either of two directions. One-way traffic should be established.

(4) *Segregation by lots.*—As a general rule, ammunition should be piled so the lot numbers are easily inspected. Quantities issued to a single unit should be, if practicable, all of one lot.

d. Fire protection.—(1) The commanding officer will appoint a fire marshal who will be responsible for the rigid enforcement of fire-preventive measures. The fire marshal will prepare rules covering all local conditions and special fire risks. He will exercise strict fire discipline within depot or dump.

(2) Fire extinguishers, water barrels, sand boxes, and other fire-fighting equipment should be provided. A supply of ropes and hooks should be kept on hand to tear down piles of boxes should they catch fire. Spontaneous combustion due to presence of greasy rags or oily waste should be guarded against. The direct rays of the sun on ammunition, especially that containing smokeless powder, is likely to cause spontaneous combustion.

e. Camouflage.—Arrangements for camouflage and concealment

should be coordinated with the representatives of the Corps of Engineers. The use of natural cover, of existing roads, of existing inconspicuous structures, and irregularity in the shape and spacing of piles will assist in the concealment of the park. Further camouflage technique is described in the field manuals of the various arms, for example, FM 4-5, FM 5-20, and FM 6-130.

156. Storage of ammunition and explosives.—*a. Classes.*—When establishing dumps, the following classes of ammunition are considered:

Boxed artillery ammunition.
Separate loading shell.
Propellent charges.
Fuzes, primers, detonators.
Mortar shell.
Bombs, fragmentation.
Bombs, demolition, general purpose, armor-piercing, depth; torpedoes and aerial mines (not containing explosive D).
Bombs (containing explosive D).
Mines, antitank.
Grenades.
Small-arms ammunition.
Pyrotechnics.
Chemical ammunition.

b. Quantity and distance.—These classes should not be stored together. Whenever practicable, the distance between piles and classes should be in accordance with paragraph 116.

c. Precautions.—(1) It is important to bear in mind the possibility of hostile fire from guns or aircraft scoring a direct hit on a pile of ammunition. This may mean the detonation en masse of that pile. Ammunition and components should be stored so that the neighboring piles will not be detonated by the explosion of one pile and so that not all of one type of component or complete round will be lost in any one explosion. There should be at least two piles of every type of ammunition or component stored. It is particularly important that fuzes, primers, detonators, etc., should be distributed as widely as storage facilities permit.

(2) Ammunition piled in the open should be raised off the ground at least 6 inches and protected from rain and direct sun by paulins. If drainage is not good, ditches should be dug around piles. All piles, indoor and outdoor, should be made with liberal use of dunnage and away from contact with walls, barricades, etc., to insure free circulation of air.

(3) During the time ammunition is in dumps, advantage should be

taken of every opportunity to place each round in good condition for firing. Lost fuze hole plugs should be replaced, burs in threads and rotating bands removed, and any other defect that might affect the serviceability of ammunition should be corrected. However, the work should be done at a safe distance from the piles.

157. Chemical ammunition.—Chemical ammunition should always be stored away from other munitions, and gas shell should always be stored on their bases. The following additional precautions should be taken in storing and handling this type:

a. Shell should be stored so that a leaky container can be removed immediately upon detection.

b. Every man working near gas shell should be equipped with a gas mask.

c. Tubes of oxygen and first-aid equipment should be placed in conspicuous places in charge of a chemical noncommissioned officer.

d. Should an accident occur and a worker be overcome, first-aid remedy will be applied and a doctor called.

e. Any type of ammunition exposed to gas must be cleaned with an oily cloth at once.

f. Conspicuous wind vanes should be set up in places where gas shell are handled.

g. Munitions containing phosphorus should always be stored alone and water-filled tubs kept available. Phosphorus ignites spontaneously when exposed to air, and submerging in water will extinguish the fire only as long as the material is kept submerged. Leaky phosphorus shell must be kept under water until they can be destroyed.

h. Pyrotechnics, incendiaries, and HC, CN-DM, and CN grenades should be kept dry.

i. Full use of dunnage should be made in storing chemical ammunition.

CHAPTER 4

DESTRUCTION OF UNSERVICEABLE AMMUNITION

Paragraph

158. General.—*a. Scope.*—At posts, camps, and stations, the only ammunition items requiring destruction are obsolete or deteriorated ammunition, which may be considered together, and duds. The instructions set forth in this chapter are for destroying limited quantities of explosives and ammunition. When larger quantities are to be destroyed or the instructions set forth cannot be complied with, special instructions will be furnished by the Chief of Ordnance. The term "limited" is defined in *d* below.

b. Responsibility and procedure.—(1) Prior to destruction, an Ammunition Condition Report (O. O. Form 7235) will be submitted to the Chief of Ordnance in order that the disposition may be approved. This report will show what parts, if any, are to be salvaged. An exception is the case of deteriorated explosives or ammunition which are found to be immediately dangerous to life or property; disposition may be made by order of the local commanding officer. Usually the post ordnance officer is also the inspector for all ordnance property; hence the responsibility both for disposition and actual destruction rests upon him. Where local breakdown of unserviceable ammunition is ordered, technical instructions for the work will be furnished by the Chief of Ordnance.

(2) Unexploded ammunition and explosives in the theater of operations in time of war often must be destroyed, giving consideration to

tactics and time available. FM 5-25 describes methods for destroying duds and other dangerous ammunition found in the field in time of war, which work is to be done under the supervision of an engineer or ordnance officer.

c. Methods.—Destruction of explosive material will be accomplished by burning, exploding, or dumping at sea, as specified below. Burying of explosives or ammunition or dumping them into waste places, pits, wells, marshes, shallow streams, or inland waterways is absolutely prohibited, except for black powder as specified below. Methods for destruction are generally based on the number of units to be destroyed, size and nature of each unit, facilities available, and topography of the land.

d. Quantity of ammunition and explosives.—By a limited quantity of ammunition and explosives, this chapter refers to the number of unexploded shell and other ammunition to be normally found on a target range or in the field as an accumulation from firings or other peacetime maneuvers. Larger quantities, generally referring to ammunition resulting from deterioration in storage or obsolescence, are destroyed according to specific instructions from the Chief of Ordnance.

e. Materials used in destroying by explosion.—Charges of ½-pound blocks of TNT or sticks of dynamite are used. These are set off either by safety fuze and a blasting cap or by a magneto and an electric blasting cap. Nitrostarch blocks have been authorized for issue in place of TNT blocks for demolition purposes. Nitrostarch is a hard, dense substance, somewhat more sensitive to friction and impact than TNT. The crushing or breaking of the nitrostarch blocks is hazardous.

f. Materials used in destroying by fire.—Fires used in destroying small ammunition components may be made from scrap lumber, wood, or such material as excelsior. When components to be destroyed are laid on the pile before lighting, the fire will be lit from a distance by means of a train of inflammable material or by a charge of black powder ignited with an electric squib.

g. Dumping at sea.—Military Establishments located near a deep sea waterway may use this method of disposal. It is particularly advantageous for shell, bombs, and loaded components which are ordinarily destroyed by explosion. In addition to the precautions in sections I and V, chapter 3, the following will be observed:

(1) Port authorities will be consulted and their regulations regarding transfer and disposal will be complied with.

(2) All material to be disposed of will be removed from its containers and packings before being dumped overboard. Instances are

on record of ammunition, thrown overboard in heavy containers, being washed up from great distances and depths.

(3) Unless a definite location for dumping is assigned by port authorities, no explosive material will be thrown overboard within 10 miles of shore.

(4) In transit the boat or barge will display a large red flag at least 10 feet above the deck and a competent man will be constantly on the alert to warn approaching craft of danger.

h. Specific type.—Information dealing with the particular type to be destroyed will be found in the paragraphs following.

159. Safety precautions.—*a.* Safety is the major consideration in destroying ammunition and explosives. It is highly advisable to test all safety devices beforehand by subjecting them to the severest test they may be called upon to withstand, provided that such test is reasonable and practicable. Only after the requirements of safety have been satisfied should salvage and economy be considered. To accomplish his purpose, the officer will often have to improvise apparatus from all available sources. It is necessary that the ordnance officer analyze and plan the destruction procedure in detail and then compare it with the general safety precautions in chapter 3 and those given below. The general safety precautions that must always be complied with in destroying ammunition are described below.

b. Explosives and ammunition will not be destroyed by detonation if magazines or other buildings are in danger of being damaged by fragments or shock. If the distance from the place of destruction is less than 800 yards, a pit or trench which will limit effectively the range of the fragments will be used.

c. All dry grass, leaves, and other inflammable materials within a radius of 200 feet from the point of destruction will be removed. Fire-fighting facilities for combating grass fires should be maintained readily available, and if practicable, the ground at the point of destruction should be wet down with water at the close of each day's operations.

d. Personnel engaged in demolition work will always take cover. Fuzes should be tested beforehand for time of burning so as to give personnel ample time to reach shelter affording substantial overhead cover and splinterproof protection. Safety fuze too large in diameter to enter the blasting cap without forcing will not be used. If an electric blasting machine is used, the wires will not be connected to the terminals until all persons have reached cover. Depending upon local conditions, temporary or permanent barricades will be provided and safety distances will be observed by all persons.

e. Pits, trenches, and bombproofs will always be provided with substantial cover, such as a layer of logs and 2 feet of earth, to limit the range of fragments. When pits are used, they should be free from stones or other objects which might form missiles.

f. Pits will not be required when the destruction takes place on an artillery range or similar site. A cover of earth 2 feet thick should be used to limit the range of fragments.

g. Explosives or ammunition to be destroyed by burning will be removed from containers, as an attempt to burn explosives or ammunition under even slight confinement may result in an explosion or detonation.

h. The quantity of matériel to be destroyed at one time will depend upon local conditions. This quantity will be carefully determined by starting with a limited number and then gradually increasing that number until the maximum which can be destroyed without damage to surrounding property or causing disturbance to civilian areas is determined. The responsible officer will make sure before he gives the signal for detonation that there is no unauthorized person in the danger area and that all authorized persons are protected by adequate cover.

i. As some types of ammunition are comparatively difficult to explode, a search of the surrounding grounds should be made after each blast and any matériel which has been thrown from the pit and not detonated should be collected and included with the next charge to be destroyed.

j. Explosives or ammunition awaiting destruction will not be piled within 200 feet of the point of destruction and will be protected from grass fires, burning embers, and flying fragments. All dry grass, leaves, and other inflammable material will be removed from the area within a radius of 50 feet of the pile.

k. In repeating burning operations, care will be taken to guard against matériel being ignited from burning residue or heat in the ground.

l. The use of improvised methods for exploding blasting caps is prohibited.

m. In case of a misfire, personnel will not approach the pit, trench, or point of detonation until a period of 30 minutes has elapsed.

n. Destruction of ammunition will never be attempted by inexperienced or untrained personnel. The number of personnel engaged in such operations will be kept at a minimum consistent with safety. No person will be permitted to work alone.

o. Guards, safety signals, and warning signs will be used as required to keep unauthorized personnel from danger areas during destruction operations.

p. In the absence of specific regulations or information covering any phase of the destruction of explosive matériel, instructions will be requested from the Chief of Ordnance.

160. Bulk explosives.—*a. Black powder.*—The safest method of destroying black powder is to dump it in a stream or body of water; but if no suitable body of water is convenient, it may be burned. In opening the containers only tools of wood or nonsparking metal will be used. The contents of one container only will be burned at one time. The powder must be removed from the container and spread out on the ground in a train about 2 inches wide, care being taken that no part of the train parallels another part except at a distance of more than 10 feet. A train of inflammable material, such as excelsior, about 5 feet long and extending to windward, must be used to ignite the powder, as the resulting flare of explosion is so quick that there will be no opportunity to withdraw. The emptied containers will be thoroughly washed on the inside with water, as serious explosions have occurred with supposedly empty black powder cans. Safety precautions, particularly paragraph 159, should be observed.

b. TNT, explosive D, and tetryl.—These high explosives will be destroyed by burning. They must not be dumped into water, as they poison it. The explosive to be burned will be removed from containers and spread in a thin layer, not more than 3 or 4 inches thick, on another layer of inflammable material, such as excelsior. A train of inflammable material will be used to ignite the explosive. Not more than 500 pounds will be burned at one time. Safety precautions in paragraph 159 should be observed.

c. Smokeless powder.—Small quantities of smokeless powder (a few boxes) up to 500 pounds may be destroyed with safety if the powder is removed from the containers and spread out on bare ground in a train of limited width and thickness dependent upon the granulation of the powder. A train of inflammable material about 25 feet long, and on the windward side, should be used to ignite the powder and allow personnel sufficient time to get away from the intense heat which is generated when smokeless powder burns. Safety precautions in paragraph 159 should be observed.

d. Other explosives.—If it is necessary to destroy other explosives, such as mercury fulminate, lead azide, picric acid, dynamite, etc., special instructions will be requested from the Chief of Ordnance.

161. Separate loading propelling charges.—Extreme precautions will be taken against sparks. Smokeless powder will be removed to the burning ground before being opened. There the powder will be removed from the bag by cutting one of the seams, care being taken not to disturb the black powder igniting charge. The empty bag and igniter should be immediately and completely submerged in water and the igniter cut open under water. The smokeless powder will be burned as prescribed in paragraph 160*c*. The igniter and cartridge bags, after having been thoroughly soaked in water for at least 72 hours, should be removed and allowed to dry in the open, and then they may be burned in a pit or trench. The soaking in water is absolutely necessary, because even the confinement of the black powder by the powder bag, slight as it may be, is sufficient to cause an explosion and the projection of the burning bags and igniters to distances of 200 feet or more. Bags and igniters awaiting destruction by fire must be kept in a securely closed container. It is permissible, when practicable, to destroy bags and igniters by dumping them in a body of water after the various sections of the quilted igniter are cut open while the bag and igniter are still submerged in water. This cutting is necessary to release air trapped in the quilted igniter sections which would cause the bags and igniters to float on top of the water.

162. Artillery shell.—*a*. The following general instructions for destroying artillery shell by detonation apply equally well to bombs, mortar shell, and other relatively large components containing high explosive. However, it must be kept in mind that bombs, mortar shell, and antitank mines are composed of as much as 60 percent explosive by weight and have relatively thin walls, as compared with the 10 to 15 percent of explosive in and the relatively heavy walls of artillery shell. Therefore, the number of units of bombs, mortar shell, and mines destroyed in one operation should be reduced accordingly. Fixed shell will be disassembled from complete rounds and destroyed in the same manner as separate loading shell (see below). Before undertaking any demolition operation, the proposed procedure will be checked against the safety precautions prescribed in paragraph 159.

b. The following general instructions contemplate the use of a pit or bombproof hut. An artillery range or similar site when available may be used. Note specially paragraph 159*e* and *f*.

c. The projectile to be destroyed will be placed on its side in a trench or pit about 4 feet deep. TNT blocks, or the equivalent, to the number specified in the following table will be placed in intimate contact with the side of the projectile and held in position by earth packed around the projectile. The TNT block is placed on its side; and, if two blocks are used, one is placed on top of the other. If three blocks are used, two are placed close together on the shell and the third on top of these. If five blocks are used, there will be two layers of two blocks each with a fifth on top. The demolition blocks are detonated by means of an electric blasting cap or miner's safety fuze and cap.

Caliber of shell to be destroyed	Number of ½-pound TNT blocks or its equivalent needed
37-mm, 2.24-inch	1
2.95-inch, 75-mm, 3-inch	2
4.7-inch, 155-mm, 6-inch	3
8-inch, 9.2-inch, 240-mm	4
10-inch, 12-inch	5
14-inch, 16-inch	6

d. One end of the required length of miner's safety fuze (see par. 159*d*) will be cut across with a sharp knife and inserted in a No. 8 blasting cap until it just touches the charge. The cap will then be lightly crimped to the fuze with a fuze crimper or suitable tool, care being taken not to press the fuze too tightly against the fulminate charge of the blasting cap. A No. 8 electric blasting cap with the necessary length of lead wire and a hand exploder may be used instead of the blasting cap with miner's safety fuze. The blasting cap will be placed in the hole drilled in the TNT block (the top block when more than one block is used) and if necessary a small amount of mud will be packed around it to hold it securely in place. In no case should a cap weaker than the ordinary commercial No. 8 blasting cap be used.

e. In case of a misfire, the precaution in paragraph 159*m* should be observed. After the blast, paragraph 159*l* should be complied with.

f. Point-fuzed shell, fitted with adapters and boosters, can be detonated without the use of TNT blocks, as a No. 8 blasting cap securely held in place in the fuze cavity with a small amount of mud packed around the top of the cap will usually insure complete detonation of loaded shell.

163. Blank ammunition for cannon.—Rounds of blank ammunition which have misfired will be destroyed locally under the supervision of a commissioned officer or personnel designated for this purpose by the corps area ordnance officer. The precautions for handling black powder, chapter 3, and for destroying ammunition, paragraphs 159 and 160, should be observed. An extractor (brass) having a wood screw thread can be used to remove the closing cap and wad; the black powder may be removed by washing or flushing out with water; and the primer removed by means of a press.

164. Bombs.—Bombs should be destroyed in accordance with paragraph 162. However, bombs have such thin walls and contain so much more explosive than shell of corresponding weight, and usually detonate so completely that extreme precautions must be taken to avoid structural damage to buildings and injuries to personnel. The destruction of bombs larger than the 100 pounds should not be undertaken without the specific approval of the Chief of Ordnance. Bombs awaiting destruction should be segregated in small piles 100 feet or more apart, and at least 300 feet from the detonating pit. Extreme precautions must be taken to protect bombs awaiting destruction against accidental detonation by fire, fragments, or sympathetic detonation.

165. Mortar shell.—Mortar shell should be destroyed in accordance with the instructions in paragraph 162. Care will be taken to limit the number destroyed at any one time and to protect shell awaiting destruction from flying fragments.

166. Small-arms ammunition.—*a.* All unserviceable caliber .22 and shotgun ammunition will be destroyed locally. Ordnance field representatives, within their jurisdiction, are charged with the disposition of all other unserviceable small-arms ammunition and accumulations from firings. Reference to OFSB 3-5 should be made for procedure to be followed in disposition.

b. Small-arms ammunition should be destroyed in a pit which is approximately 6 feet square and 4 feet deep. An inclined chute such as a piece of 2-inch pipe should be provided, and this chute should be placed so that one end is over the center of the pit and the other behind the barricade. Precautions should be taken to baffle the open end behind the barricade so that the operator cannot look down the pipe. A hot fire should be built in the pit and then the pit should be covered with a piece of sheet iron or other suitable material to confine flying fragments. The cartridges should be fed into the fire through the pipe and care should be taken to prevent an accumulation of unexploded ammunition in the pit.

167. Small components except primers.—*a.* These components, artillery and grenade fuzes, boosters, detonators, and similar matériel, may be destroyed either by burning or by exploding. For destruction of primers see paragraph 168.

b. In destruction by burning, the same instructions given in paragraph 166*b* for the destruction of small-arms ammunition should be followed. Caution should be exercised in introducing components into the fire because normal action cannot be expected under intense heat. The explosion of a previously introduced component should be heard before introducing another.

c. In accomplishing the destruction of these components by explosion, a small number of components, depending upon the type and

kind, should be placed in an open container and in intimate contact with one another. This container should then be placed in a pit or trench approximately 4 feet deep. On top of each container, in intimate contact with the components, should be placed one or more TNT blocks fitted with an electric blasting cap or with a common blasting cap and safety fuze. The pit should then be covered with a layer of logs and earth or other suitable cover, and then the components should be detonated in accordance with the safety precautions outlined in paragraphs 159 and 162.

168. Primers.—*a.* Large primers, 100-grain or larger, may be destroyed by burning according to the instructions for destruction of small-arms ammunition in paragraph 166*b*. Primers, other than small-arms primers, are dropped one at a time into the fire. Large primers will be destroyed only in this manner, as they are subject to explosion en masse if destroyed by burning in large quantities.

b. Primers, except the 100-grain or larger primers, may be burned in a trench approximately 2 feet deep, 1 foot wide, and of sufficient length to accommodate the number of primers to be burned at one time. The trench should be prepared with a quantity of excelsior or similar combustible material sufficient to insure a hot fire throughout its length. The primers should be removed from boxes and placed on the excelsior before the fire is lighted. Pasteboard cartons need not be opened before they are placed in the trench. A piece of sheet metal should be placed over the trench, to confine fragments as much as possible. Sufficient space should be left to allow a draft through the trench. After the primers and cover are in place, a train of combustible material leading into the pit should be prepared and lighted. Personnel should then take cover or withdraw to a safe distance.

c. If a suitable tank or kettle is available for use, a small number of primers may be placed in it and a small-mesh screen placed over the top. By building a fire underneath, the primers will be exploded. A convenient receptacle is an iron tank, cut in half longitudinally and the open side placed down on railroad iron or other suitable grating that will not let the primers drop into the fire. A large hole, approximately 12 inches in diameter, with a pipe located above the height of a man's head, should be provided and about 50 primers put in at one time. The boiler should be equipped with a smokestack so that a draft will be formed through the grating. Packing material, if inflammable, need not be removed from the primers.

d. If a burning pit constructed of railroad iron or similar material is available a fire may be built in it and a box of primers destroyed at

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one time, provided the packing is inflammable, by throwing the box into the pit and taking cover.

e. The 20-grain and 40-grain primers may be destroyed by building a firebox over which a basket of primers may be pulled on railroad iron from behind a barricade. The fire should be started before the primers are pulled over it. When all pri ners have been fired, the basket should be pulled off, emptied, cooled, reloaded, and again pulled over the fire.

f. The stock of primers awaiting destruction will not be allowed within 800 feet of the burning operations, and great care will be taken to protect the pile from accidental ignition by flying fragments or sparks. This stock will be limited to a day's supply. Other applicable regulations, contained in paragraph 159, will be strictly observed.

169. Grenades.—*a. General.*—Grenades may be destroyed by burning or exploding in accordance with the following instructions. A strict compliance with applicable regulations of paragraph 159 is essential for the protection of personnel and property. Destruction by explosion should, in general, be applied to high explosive grenades, whereas destruction by burning is applied generally to other types of grenades.

b. Destruction by explosion.—Not more than 20 grenades should be placed in a pit about 4 feet deep. They should be piled so that they come in close contact, and on top of the pile there should be placed, in intimate contact, three ½-pound TNT blocks, one of which is provided with a No. 8 electric blasting cap or No. 8 blasting cap fitted with several feet of safety fuze. The grenades and TNT blocks should be covered with a layer of earth about 1 foot thick and tamped lightly to obtain the maximum efficiency of the TNT blocks, and the pit should be covered as prescribed in paragraph 159*f*.

c. Destruction by burning.—A pit 2 feet square by 3 feet deep fitted loosely with an iron plate or heavy board cover is used. Grenades should be put in the fire one at a time. Another should not be put in until the previous grenade is exploded. Care should be taken in introducing explosives into the fire as normal action cannot be expected under intense heat. The time to investigate an unusual delay in the explosion of a grenade is only after the fire has burned out and the pit is cold. An inclined chute baffled at the open end may be used, instead of dropping them singly and covering each time.

170. Pyrotechnics.—*a. General.*—Pyrotechnics, except photoflash bombs and parachute flares, will be destroyed in accordance with the instructions for burning primers, paragraph 168*b*.

b. Parachute flares.—Parachute flares will be destroyed by burning

in a vertical position on the ground and in the open. The individual flares must be located at least 4 feet apart and placed on top of a layer of combustible material. After lighting the train of combustible material, personnel should take cover and observe safety distances.

c. Photoflash bombs.—Photoflash bombs are dangerous and should be handled with care. They should be destroyed by the use of TNT blocks and destroyed similarly to the procedure for artillery shell, paragraph 162. Duds of photoflash bombs should not be handled but destroyed in place in accordance with instructions set forth in paragraph 173. Due to the thinness of the case, a single block of TNT is sufficient to accomplish destruction. A strict compliance with the applicable regulations of paragraph 159 is essential.

NOTE.—Due to the brilliancy of the flash, it is detrimental to vision to watch the destruction of photoflash bombs even at distances prescribed in this manual as safe against fragments.

171. Chemical ammunition.—*a.* In general, grenades and shell loaded with chemical filler should be destroyed in a manner similar to that prescribed in paragraph 162 for destroying artillery shell. However, before destroying chemical ammunition special instructions should be obtained from the Chief of Ordnance concerning any exceptional hazards. When a leaking shell or component is located, the officer in charge of the magazine will be notified in order that he may direct the disposition of the shell. As chemical shell contains a comparatively small amount of explosives, the charge of TNT blocks to be used for demolition should be as follows:

Chemical shell or component	Number of ½-pound TNT blocks or equivalent
75-mm shell	4
155-mm shell	5
8-inch shell	6
3-inch, 4-inch, and 81-mm chemical mortar shell	2
4.2-inch chemical mortar shell	3
8-inch chemical mortar shell	8
Bomb, 5-pound	1
Bomb, 25-, 30-, and 50-pound	2
Bomb, 100-pound	8

b. Immediately hazardous unserviceable chemical ammunition may be destroyed by exploding in the open if a sufficiently isolated area is available. The point where the shell is exploded should be chosen so that personnel can be excluded for a period of approximately 48 hours from the area 1 mile downwind from the point where the shell is exploded. All personnel must be prevented from passing within a distance of 150 yards from the point where the shell is exploded for a period of about 2 weeks. Where a sufficiently isolated area is not available, single unserviceable gas-filled shell may be destroyed in a pit 6 feet deep. The shell with its bursting charge is placed at the bottom of the pit, the pit is back-filled, and the shell exploded. Five gallons of freshly prepared bleaching solution should be poured on the fill and then sufficient dry bleach should be scattered over the fill to cover the disturbed ground to a depth of 2 inches. A permanent sign should be placed on the fill, prohibiting digging in the vicinity.

172. Antitank mines.—If marks on the mine or on the ground indicate that it has been run over by a vehicle, the mine should be considered as a dud and destroyed in place by detonation with a TNT or nitrostarch block, without handling or jarring the mine. Only mines that have not been tampered with, handled, or disturbed in any manner may have the safety fork replaced and then taken up. The safety fork must be replaced before any handling of the antitank mine or before removing the fuze. Unserviceable antitank mines will be destroyed in the same manner and with the same precautions as bombs.

173. On target ranges.—*a. General.*—Explosive missiles which have failed to function after firing are termed "duds." AR 750-10 prescribes that, after firing on a range has been completed and before free access to it is allowed to personnel in general, the range will be thoroughly policed and all duds destroyed by competent personnel. Duds of photoflash bombs or aircraft flares released during fligh over land areas other than target ranges will be recov red and destroyed.

b. Safety precautions.—Target ranges are made dangerous by flying missiles during target practice and by unexploded ammunition which may remain on the range after target practice. Safety precautions should therefore include means for preventing trespass upon the target range by unauthorized or careless persons and for removing from the range all unexploded ammunition which as been fired. In addition to the safety measures employed at and n ar the firing line, such as red flags, markers, or fences, the boundary or terrain which is likely to receive missiles from the firing line should be placarded with signs which indicate the danger zone and the hazards attendant upon entering such zones at specified times. The signs should also emphasize the dangers connected with picking up unexploded ammunition and should prohibit either trespass on the range or the removal of souvenirs from areas, under penalties provided by law. The placarding of the target ranges is a matter of public safety and will never be neglected.

c. Destroying duds.—(1) The policing of a target range and insuring the safety of the command are functions of the commanding officer. Immediately after target practice is completed, the entire range should be carefully policed for unexploded ammunition, under the supervision of an authorized officer who is thoroughly familiar with the dangers incident to such operations. Unexploded projectiles and other components of ammunition which have been fired are dangerous to handle and should not be touched or jarred where it is practicable to destroy the same by the use of dynamite or TNT blocks. However, unfuzed duds may be handled with comparative safety.

(2) In those rare cases in which it is necessary to remove a dud from any location before destroying it, all operations connected with this procedure should be done either by or under the direct supervision of personnel who are thoroughly familiar with the dangers of such an operation and who have qualified to do this work.

(3) To place an unexploded fired projectile on its base or nose is to invite disaster, as such an operation will cause movement of the internal fuze parts and may cause the projectile to explode. No attempt should be made to disassemble a round of unexploded ammunition except by experts of the Ordnance Department who are specifically assigned to such work.

(4) Duds on the target range, such as unexploded projectiles, fuzes, grenades, etc., can usually be destroyed in place with TNT blocks or sticks of dynamite placed in intimate contact with the dud and in all cases covered with sandbags or earth to limit the range of the fragments. Shell exploded on the ground surface without tamping may send fragments 1,000 yards, and all within this danger zone will take cover when the charge is fired. Personnel should never be within 100 yards of a projectile when it explodes, even if suitable protection is at hand. The general instructions for destroying duds on the target range are similar so far as possible to those described for destroying artillery ammunition, paragraph 162. Duds of photoflash bombs are destroyed in accordance with this paragraph and paragraph 170. The safety precautions in paragraph 159 should be carefully observed.

(5) Gas shells or bombs should be handled in the same manner as other projectiles. Holes or trenches in which gas shells have been exploded must be filled or decontaminated and gas masks worn during the work. Work should always be done on the windward side of the area where gas shells are exploded.

(6) As an added precaution, after the destruction of duds has been completed the officer in charge of the work will personally superintend a thorough search of the area in order to insure that no duds have been overlooked.

APPENDIX I

GLOSSARY

Adapter.—Threaded bushing used to adapt a fuze to a projectile or bomb.

Adapter-booster.—Adapter and booster assembled as a unit for a bomb or shell.

Aircraft bomb.—*See* Bomb.

Aircraft signal.—Signal for use from aircraft.

Aliquot part charge.—Separate loading propelling charge divided into equal sections; also referred to as equal section charge.

Allways fuze.—Fuze used with mortar shell which will function regardless of the part of the shell striking the target.

Amatol.—A high explosive; a mixture of ammonium nitrate and TNT.

Ammonal.—A high explosive containing TNT and powdered aluminum.

Ammunition.—Munitions and components, containing an explosive element, expended in combat.

Ammunition data card.—A 5- by 8-inch card giving pertinent information necessary for complete identification and for handling, storage, and use.

Ammunition lot.—A batch of rounds or components, each of which is manufactured by one manufacturer under uniform conditions, and which is expected to function in a uniform manner.

Ammunition lot number.—Number which identifies an ammunition lot.

Antitank mine.—Fuzed ammunition, buried or concealed, which functions when a tank passes over it.

Arming.—To put a fuze in a condition whereby it can function.

Arming pin.—A pin in aircraft bomb fuzes which serves to arm the fuze upon being withdrawn.

Arming vane.—A miniature propeller which acts to arm aircraft bomb fuzes, after the bomb has fallen some distance below the airplane.

Arming wire.—A length of wire which, while attached, prevents a fuze from arming.

Armor-piercing.—Bullets and projectiles having a hardened steel element designed to pierce armor plate.

Artillery ammunition.—Ammunition fired from cannon.

Auxiliary booster.—An additional booster required for a large bursting charge which ordinarily would not be properly detonated by a booster alone.

Ball cartridge.—General purpose small-arms ammunition for standard service.

Ballistic coefficient.—The numerical measure of the ability of a projectile to overcome air resistance and maintain its velocity.

Ballistics.—That branch of applied mechanics which treats of the motion of projectiles, internal ballistics dealing with the motion within the gun and exterior ballistics dealing with the motion after leaving the gun.

Ballistite.—A double-base type of propellent powder used in some small-arms and mortar ammunition.

Bandoleer.—A pocketed belt used as a means of carrying small-arms ammunition so as to be readily accessible.

Barrel.—The tube of a gun.

Base and increment charge.—A semifixed or separate loading propelling charge consisting of a base section and one or more increment sections usually of less weight than the base section.

Base charge.—(1) A black powder charge in the base of shrapnel. (2) A propellent charge for inner zone howitzer firing.

Base cover.—A metal disk secured to the base of high explosive shell to prevent hot gases from coming in contact with the bursting charge through possible flaws in the base of the shell.

Base-detonating fuze.—A fuze located in the base of a projectile.

Black powder.—A low explosive consisting of an intimate mixture of sulfur, charcoal, and saltpeter.

Blank ammunition.—Ammunition without projectile used in saluting, signaling, or simulating fire.

Blasting cap.—A thin copper shell containing a sensitive explosive and fired by a slow-burning safety fuze or an electric current.

Blinker.—An aircraft pyrotechnic signal burning with intervals of light separated by a period of darkness.

Boat-tail.—A tapered base of a projectile.

Body.—The portion of a projectile immediately to the rear of the bourrelet.

Bomb.—A container of explosives or chemicals or both with fuze, dropped by aircraft.

Booster.—A high explosive component which amplifies the explosion of the fuze to detonate properly the bursting charge of a shell or bomb.

Bore.—The opening through the length of the barrel of a gun.

Bore safe.—A bore-safe (detonator-safe) fuze is one in which the explosive train is so interrupted that prior to firing, and while the projectile is still in the bore of the cannon, premature action of the bursting charge is prevented should any of the more sensitive elements, primer and/or detonator, malfunction.

Bouchon assembly.—Name formerly applied to grenade fuzes.

Bourrelet.—The machined raised portion of a projectile which bears on the bore.

Breech.—The end opposite the muzzle of a gun.

Breech mechanism.—A mechanical device for closing the rear end of the chamber or bore of a gun after loading, and for firing the inserted round of ammunition.

Brisance.—The shattering ability of high explosives.

Bullet.—Projectile of small-arms ammunition.

Bull's-eye powder.—A double-base type of propellent powder used in small-arms ammunition.

Burster.—An explosive element used in chemical shell to open the shell and disperse the contents.

Bursting charge.—The explosive filler of ammunition.

Caliber.—(1) The diameter of bullet or projectile, expressed in inches or millimeters. (2) The measure of length of a cannon.

Canister.—An artillery projectile, containing only small balls, which disrupts upon leaving the muzzle of the weapon, producing a shotgun shell effect.

Cannelure.—A groove.

Cannon.—A gun, howitzer, or mortar, on a mount or carriage.

Cartridge.—A complete round of small-arms ammunition.

Cartridge bag.—Cloth bag used to hold the propelling charge for semifixed and separate loading ammunition.

Cartridge case.—A brass case containing the propellent powder charge, used with small arms, fixed, and semifixed ammunition.

Cartridge storage case.—A waterproof metal or fiber container in which separate loading propelling charges and igniters are stored, handled, and shipped.

Casualty agent.—A chemical agent of such characteristics that a toxic or lethal concentration can be set up under conditions encountered in the field.

Centrifugal force.—The force due to rotation. It is used to arm certain fuzes while projectile is in flight.

Chain.—Type of pyrotechnic signal in which several colored lights burn in a vertical line.

Chemical agent.—A substance which, by its ordinary and direct action, produces a toxic effect, a screening smoke, or an incendiary action. *See* Gas, Smoke, and Incendiary.

Cluster.—(1) A pyrotechnic signal in which a group of stars burns simultaneously. (2) An assembly of several bombs released together.

Complete round.—All the ammunition components necessary to fire a weapon once.

Cordite.—A double-base propellent powder.

Creep action.—The tendency of fuze parts in a moving projectile to move forward.

Cut (applied to time fuzes.)—To set (a fuze).

Data card.—*See* Ammunition data card.

Day of supply.—The estimated average expenditure of various items of supply per day in campaign, expressed in quantities of specific items or in pounds per man per day.

Decontamination.—The act of removing or neutralizing chemical agents from material structures and ground.

Demolition.—Destruction due to the blast or mining effect of high explosive ammunition.

Detonation.—The very rapid explosion of a high explosive.

Detonator.—A sensitive explosive used in an explosive train.

Distance wadding.—A cardboard cylinder used in fixed ammunition in which the powder does not fill the cartridge case, to keep the propellent powder around the primer.

Double-base powder.—A propellent powder containing nitrocellulose and nitroglycerin.

Drill ammunition.—Inert or dummy ammunition used for training personnel.

Dropping safe.—Releasing an aircraft bomb or flare so that it will not function on impact. Some flares, however, *may* function on impact, even when dropped safe.

Dud.—Explosive ammunition which has failed to function.

Dummy ammunition.—*See* Drill ammunition.

E. C. Powder.—A smokeless powder containing inorganic nitrates; used as a bursting charge in fragmentation grenades.

Equal section charge.—A propelling charge for separate loading ammunition divided into equal sections.

Erosion.—Wearing away of the inner parts of a gun or cannon as the result of mechanical wear and action of powder gases.

Explosion.—The sudden generation of a large volume of highly heated gases with resultant pressures.

Explosive.—A substance or mixture which may, upon application of heat or shock, undergo a very rapid chemical change producing a great amount of heat and a large volume of gas.
Explosive D.—Ammonium picrate, a high explosive.
Explosive filler.—The bursting charge of ammunition.
Explosive train.—The step-by-step arrangement of explosives from a small charge of sensitive explosive to a large charge of relatively insensitive explosive.
Extractor groove.—The groove around the head of the cartridge case to provide a grip for the mechanical extractor of the weapon.
Extractor rim.—A rim or flange around the head of a cartridge case to provide a grip for the mechanical extractor of the weapon.

Filler.—Contents carried within an ammunition container, explosive, chemical, or inert.
Firing.—The act of discharging a weapon in the normal manner.
Firing pin.—A pin used to initiate the action of a detonator or primer.
Firing tables.—Collection of data, chiefly in tabular form, intended to furnish the ballistic information necessary for conducting the fire of a particular model of gun and mount with specified ammunition.
Fixed ammunition.—Ammunition loaded in one operation into the weapon, the cartridge case being permanently attached to the projectile and the propellant not being variable.
Flare.—A pyrotechnic used for illumination.
Flare-back.—The passing to the rear of unburned gases from the breech of the weapon, resulting in a flame upon contact of the gases with the air.
Flash.—*See* Muzzle flash.
FNH powder.—A smokeless propellent powder which is flashless and nonhygroscopic. When used in cannon in which flash occurs, it is termed NH powder.
Fragmentation.—The shattering into many fragments of an item of ammunition by its bursting charge.
Fuze.—(1) Tube or cord, filled or impregnated with combustible matter, for igniting an explosive charge after a predetermined delay.
(2) A mechanical device designed to initiate the function of ammunition at the time and under the circumstances desired.
Fuze setter.—A mechanical device for setting time fuzes for the calculated time interval.
Fuze wrench.—A wrench designed to tighten fuzes in a projectile.

Gas.—A chemical agent which, in field concentrations, produces a toxic or irritant effect. The term includes irritant smoke.
Grading.—The assignment of lots of ammunition to use in specific weapons or the assignment of priority of use.
Granulation.—The size and form of grains of propellent powder.
Grape.—A seldom used form of projectile which releases or breaks up into several large balls.
Grenade.—Explosive or chemical missile thrown by hand, or projected by rifles or other launchers.
Grenite.—A nitrostarch explosive.
Gun.—A cannon with a long barrel, generally about 35 to 60 calibers long.
Guncotton.—Nitrocellulose of high nitration.
Gunpowder.—*See* Black powder.

Hangfire.—The temporary failure of a primer, igniter, or propelling charge to function.
Harassing agent.—Any chemical agent used to force masking and thus retard military operations.
High explosive.—Explosive functioning with high order detonation.
High order detonation.—A complete and instantaneous detonation.
High-pressure test cartridge.—Small-arms ammunition to proof-test small arms.
Howitzer.—A cannon with a medium length barrel, generally about 25 to 35 calibers long.
Hung bomb.—A bomb which accidentally remains attached to the airplane after release from the rack, for example, by the arming wire.
Hung striker.—A striker of a grenade fuze which failed to strike the primer, resulting in a dud.
Hygroscopicity.—The tendency of material to absorb moisture.

Identification.—Complete identification of ammunition consists of type, size, manufacturer's symbol, lot number, and grade.
Igloo.—A concrete-arch earth-covered magazine.
Igniter.—A black powder charge, usually in the form of a pad or core, attached to separate loading propelling charges.
Illuminating shell.—Shell used to illuminate an objective. A time fuze acts to release a flare which is suspended by a parachute.
Incendiary.—A chemical agent whose principal effect is to generate sufficient heat to cause the ignition of combustible substances with which it is in contact.
Inertia.—Property of matter which tends to resist acceleration.

Initial velocity.—*See* Muzzle velocity.

Instantaneous fuze.—*See* Nondelay fuze.

Interrupter.—A device in a fuze which prevents the fuze from acting until the projectile leaves the bore of the gun.

Irritant gas.—A nonlethal gas characterized by an intensely irritating physiological action.

Irritant smoke.—The common designation of a sternutator type of irritant gas that can be disseminated as extremely small solid or liquid particles in the air.

Lacrimator.—An irritant that causes copious flow of tears and intense, though temporary, eye irritation.

Land mine.—Fuzed ammunition designed to function on land and normally concealed.

Lands.—The raised portion of the rifling of guns and cannon.

Lead azide.—A high explosive almost as sensitive as mercury fulminate.

Lifting plug.—A plug screwed in the nose of unfuzed projectiles and containing an eyebolt or ring on the end.

Limited standard.—Item once used and now obsolete except that existing stocks will be used.

Livens projector.—A mortar-type weapon used by chemical troops.

Long delay fuze.—A fuze designed to function after complete penetration of the target.

Lot number.—*See* Ammunition lot number.

Low explosive.—A relatively slow-burning explosive which does not ordinarily detonate.

Low order detonation.—An incomplete and relatively slow detonation, being more nearly a combustion than an explosion.

M series.—Referring to a series designated by model numbers in distinction to a series designated by mark numbers.

Magazine.—Any structure that is used for storing ammunition or explosives.

Magazine area.—Area separated from administration and living areas, fenced and guarded, for the location of magazines.

Malfunction.—Failure of ammunition to function in a normal or expected manner.

Mark number.—A numerical designation for ordnance items preceded by the abbreviation Mk. *See* Model number.

Matrix.—A composition holding balls in place in shrapnel.

Mechanical time fuze.—A fuze whose time action is controlled by a clocklike mechanism.

Mercury fulminate.—A sensitive high explosive used as a detonator.

Mine.—*See* Land mine; Antitank mine.

Misfire.—Failure of a primer or propelling charge to function.

Model number.—The standard numerical designation assigned to any item upon its adoption.

Mortar.—(1) A cannon with a short barrel, generally 10 to 15 calibers long. (2) A portable smooth-bore, muzzle-loading, trench warfare weapon.

Mortar ammunition.—Generally, ammunition used in smooth-bore mortars and having fins for stability in flight.

Multisection propelling charge.—A propelling charge for artillery projectiles consisting of more than one section.

Munitions.—Ammunition, explosives, and all necessary war materials.

Muzzle.—The end of the barrel of a gun from which the bullet or projectile issues.

Muzzle flash.—An observable spurt of flame at the muzzle of a gun when firing.

Muzzle velocity.—The velocity of the projectile as it leaves the muzzle of the gun. Also called initial velocity.

NH powder.—*See* FNH powder.

Nitrocellulose.—A propellant produced by nitrating cotton (cellulose).

Nitroglycerin.—A high explosive produced by nitrating glycerin.

Nitrostarch.—A high explosive produced by nitrating starch.

Nomenclature.—*See* Standard nomenclature.

Nondelay fuze.—A fuze designed to burst the projectile outside a hard surface before penetration or ricochet.

Nonpersistent gas.—A chemical agent whose concentration at the point of discharge is not sufficient after 10 minutes to require protection.

Obturation.—To stop up or close by the expansion of a part, usually in reference to the sealing of the breech of a gun to prevent the escape of gas to the rear.

Ogive.—The front, curved portion of a projectile.

Penetration.—The distance to which a projectile sinks into the target at which it is fired.

Percussion.—The initiation of an explosive by means of a blow.

Persistent gas.—A chemical agent whose concentration at the point of discharge is sufficient after 10 minutes to require protection.

Photoflash bomb.—A pyrotechnic, dropped from aircraft, producing a flash sufficiently bright for photographic purposes.

Powder grains.—*See* Granulation.

Powder rings.—Increment sections of a propelling charge in the form of rings, for mortar ammunition.
Powder train.—Black powder element in a fuze, the time of burning of which controls the functioning of the fuze.
Practice ammunition.—Ammunition used for target practice.
Premature.—Term applied to a projectile functioning before the desired time.
Primer.—A device which functions as an initiator.
Primer charge.—A charge of black powder in artillery primers which transmits the flame to the propelling charge.
Primer-detonator.—An assembly of a primer, detonator, and sometimes a delay element, used in bombs.
Primer mixture.—A small quantity of a sensitive explosive in a primer which acts as an initiator.
Priming composition.—*See* Primer mixture.
Projectile.—Any missile projected by means of explosive force from a weapon.
Propellant.—The explosive which, upon ignition, propels the projectile from gun or cannon.
Propelling charge.—A definite quantity of explosive used as a propellant.
Pyro powder.—*See* Pyrocellulose.
Pyrocellulose.—Nitrocellulose, of lower nitration than guncotton, used in smokeless powder propellants.
Pyrotechnics.—Ammunition, consisting of chemical mixtures, used as signals and illuminants.

Quantity-distance tables.—Data for the proper and safe storage of ammunition and explosives.

Rifling.—The spiral grooving in the bore of a gun or cannon which imparts rotation to the projectile.
Rotating band.—A raised copper or gilding metal band near the base of a projectile which imparts rotation to the projectile when engraved by the rifling of a gun.
Round.—*See* Complete round.

Safe.—*See* Dropping safe.
Salvo.—One shot per gun, fired simultaneously or fired in a certain order with a specified time interval between rounds.
Screening agent.—*See* Smoke.
Semifixed ammunition.—Ammunition loaded into the cannon in one operation and whose propelling charge may be adjusted for zone firing.

Separate loading ammunition.—Ammunition the components of which are loaded into cannon separately.
Service ammunition.—Ammunition used or intended for use in combat.
Service markings.—Painting, stenciling, and stamping on ammunition to impart information necessary for intelligent handling, storage, and use.
Set-back.—The effect of inertia on the components of a projectile on firing.
Shell.—A hollow projectile. It may contain explosive, chemical, or inert filler, or no filler.
Short delay fuze.—A fuze designed to function projectiles after ricochet or before complete penetration in hard ground.
Shot.—A projectile which is solid or contains no bursting charge. Also applied to some armor-piercing projectiles containing a reduced explosive charge.
Shot shell.—*See* Shotgun shell.
Shotgun shell.—Small-arms ammunition containing small balls or shot which scatter upon firing.
Shrapnel.—An artillery projectile containing small balls which are expelled from the shell body when its time fuze functions.
Signals.—Pyrotechnics projected from ground or aircraft to produce colored lights.
Single-base powder.—A propellent powder containing nitrocellulose as its base, also known as straight nitrocellulose powder.
Slivers.—Unburned fragments of multiperforated powder grains ejected from a cannon during firing.
Small arms.—Rifles, automatic rifles, pistols, and machine guns up to caliber .60, and shotguns.
Small-arms ammunition.—Ammunition fired from small arms.
Smoke.—A chemical agent which, when released from its container, spreads through the atmosphere in the form of liquid or solid particles producing an obscuring fog.
Smokeless powder.—Nitrocellulose propellent powders.
Spider.—In an antitank mine, the device for functioning the fuze.
Square-base.—Portion to the rear of the rotating band of a projectile, which is cylindrical rather than tapered.
Stacked.—Arrangement of powder grains end to end instead of at random in a separate loading propelling charge.
Standard contour fuzes.—Point-detonating fuzes having standard shape, size, and weight.
Standard nomenclature.—A specific descriptive name by which each ordnance item or assembly is designated. Used in all official reference to the item or assembly.

Star.—A pyrotechnic signal which burns as a single light.
Sternutator.—A chemical agent which, when breathed in extremely low concentrations, causes coughing, sneezing, or headache, followed by nausea, and temporary physical debility.
Strip powder.—Smokeless powder manufactured in the form of strips.
Subcaliber ammunition.—Ammunition used with subcaliber mounts and tubes, that is, weapons of small caliber used to simulate the firing of the larger caliber weapon.
Superquick fuze.—A fuze designed to function immediately upon impact.
Supersensitive fuze.—A fuze designed to function on impact with a very light target, such as an airplane wing.
Surveillance.—All steps necessary for the maintenance of ammunition stores in usable condition. It includes inspection, testing, and maintenance.

Target practice ammunition.—*See* Practice ammunition.
Tetryl.—A sensitive explosive which is standard for use in boosters and bursters.
Thermit.—A mixture producing molten iron upon ignition; used as an incendiary agent.
Time fuze.—A fuze designed to function a predetermined time interval after firing.
Toxic.—A substance which, acting through its chemical properties and by its ordinary action, produces a harmful physiological reaction when applied to the body externally, when breathed, or when taken in small doses internally. All war gases are toxic.
Tracer.—A burning composition placed in shell and bullets which shows the path of the projectile.
Trajectory.—The curve in space traced by a projectile in flight.
Trench mortar.—A smooth-bore portable mortar.
Trimonite.—A high explosive used as a substitute for TNT as a bursting charge.
Trinitrotoluene (TNT).—A high explosive which is the standard bursting charge for ammunition.
Triton block.—Block of TNT used for demolition purposes.

Unequal section charge.—A propelling charge divided into a number of unequal sections, as three ¼ sections and two ⅛ sections.
Unequal related section charge.—*See* Unequal section charge.
Unfixed shell.—Shell for fixed ammunition which are loaded but not yet assembled to cartridge case. Stored as separate loading shell.

Unit of fire.—An arbitrary unit of measure for ammunition supply representing a specified number of rounds per weapon.
Using arms.—The branches of the Army which habitually use or expend the particular ammunition under discussion.

Very pistol.—A type of pistol for firing light signals.
Vesicant.—A chemical agent which produces inflammation, burns, and the destruction of tissue.

Weapon.—An instrument of combat; anything used physically against an enemy such as a gun, sword, shield, grenade, etc.
Web.—Minimum thickness between two adjacent perforations, or between perforation and edge, of a powder grain.
Weight zone.—A grouping of a number of shell of the same weight and same lot number for accuracy in firing.

Zone of fire.—An area of a certain range determined by considering weight of projectile and quantity of propelling charge.
Zone, weight.—*See* Weight zone.

APPENDIX II

ABBREVIATIONS

AA	Antiaircraft
AM	Amatol
Am	Ammunition
AP	Armor-piercing; amber star parachute
AR	Army Regulations
AT	Antitank
Auto	Automatic
BD	Base detonating
BDF	Base-detonating fuze
BT	Bombing table
C1	First change
cal.	Caliber
CG	Phosgene
cml.	Chemical
chg.	Charge
C. I.	Center of impact; cast iron
Cl	Chlorine
CN	Chloracetophenone (Tear gas)
c/r (C. R.)	Complete Round
C. R. C.	Complete Round Chart
C. S. C.	Cartridge storage case
CWS	Chemical Warfare Service
Demo.	Demolition
diam.	Diameter
DM	Adamsite, sneeze gas
DP	Deck-piercing
drg. (dwg)	Drawing
Exp. (Ex.)	Explosive
FM	Field Manual; titanium tetrachloride, smoke
FNH	Flashless, nonhygroscopic
Frag.	Fragmentation
FSMWO	Field Service Modification Work Order
Gn	Gun
GH	Gun or howitzer
gr.	Grain
HE	High explosive
HEI	High explosive incendiary

How	Howitzer
HS	Mustard gas
ICC	Interstate Commerce Commission
IMR	Improved military rifle
in.	Inch
lb.	Pound
LD	Long delay
LE	Low explosive
LP	Livens projector
M	Model; manufacture to be continued; mortar
M1	Lewisite
Mk.	Mark
mech.	Mechanical
mm	Millimeter
Mod.	Modification
MV	Methyl violet; muzzle velocity
NC	Nitrocellulose
ND	Nondelay
NG	Nitroglycerin
NH	Nonhygroscopic
obs.	Obsolete
OFSB	Ordnance Field Service Bulletin
OFSC	Ordnance Field Service Circular
OO (O. O.)	Ordnance Office
OPSI	Ordnance Publications for Supply Index
OSM	Ordnance Safety Manual
OTCM (OCM)	Ordnance Technical Committee Minutes
oz.	Ounce
PD	Point-detonating
PDF	Point-detonating fuze
pdr.	Powder; pounder (15-pdr.)
perc.	Percussion
proj.	Projectile
PS	Chlorpicrin
rd. (rds.)	Round(s)
S	In SNL's, in stock for issue and manufacture discontinued; on shell, smoke producer together with HE filler
SD	Short delay
SDT	Shell destroying tracer
sec.	Second
SNL	Standard Nomenclature List
SP	Smokeless powder

SQ	Superquick
T	Tentative model designation
T/A	Table of allowances
T/BA	Table of Basic Allowances
TH	Thermit
TM	Technical Manual; Training Manual
TNT	Trinitrotoluene
TP	Target practice; tank piercing
TR	Technical Regulations; Training Regulations
w/	With
WD	War Department
w/o	Without
WP	White phosphorus; white star parachute

APPENDIX III

LIST OF REFERENCES

1. **Standard Nomenclature Lists.**—*a. Ammunition for small arms.*

Ammunition, revolver and automatic pistol ---------- SNL T-2
Ammunition, rifle and automatic gun ---------- SNL T-1
Ammunition, small arms, obsolete, and nonstandard --- SNL T-6
Miscellaneous service components of small-arms ammunition and instruction material for field service account ---------- SNL T-4
Shells, shotgun ---------- SNL T-3

b. Bombs, grenades, and pyrotechnics.

Ammunition instruction material for grenades, pyrotechnics, and aircraft bombs ---------- SNL S-5
Bombs, aircraft, all types ---------- SNL S-1
Grenades, hand and rifle ---------- SNL S-3
Grenades, pyrotechnics, and aircraft bombs ---------- SNL S-6
Pyrotechnics, military, all types ---------- SNL S-4

c. Cleaning, preserving, and lubricating materials --- SNL K-1

d. Firing tables and trajectory charts ---------- SNL F-69

e. Harbor defense, heavy field, and railway artillery.

Ammunition, fixed, including subcaliber ammunition -- SNL P-4
Ammunition instruction material ---------- SNL P-7
Ammunition, obsolete, and nonstandard ---------- SNL P-9
Charges, propelling, separate loading ---------- SNL P-3
Fuzes, primers, blank ammunition, and miscellaneous items ---------- SNL P-6
Projectiles, separate loading ---------- SNL P-1

f. Pack, light, and medium field artillery.

Ammunition, blank ---------- SNL R-5
Ammunition, fixed, all types ---------- SNL R-1
Ammunition, instruction material ---------- SNL R-6
Ammunition, obsolete, and nonstandard ---------- SNL R-8
Ammunition, trench mortar, including fuzes, propelling charges, and other components ---------- SNL R-4
Ground mines and fuzes, demolition matériel for use in policing target ranges, and ammunition for simulated artillery and grenade fire ---------- SNL R-7

Projectiles and propelling charges, separate loading, all types	SNL R-2
Service fuzes and primers	SNL R-3
Current Standard Nomenclature Lists are as tabulated here. An up-to-date list of SNL's is maintained as the "Ordnance Publications for Supply Index"	OPSI

2. Explanatory publications.—*a. Ammunition, all types.*

Ammunition, general	OFSB 3-1
Ammunition—reimbursement prices	OFSB 3-7
Ammunition nomenclature and shipping names	OFSB 3-12
Ammunition condition report	O. O. 7235
Explosives and demolitions	FM 5-25
Military explosives	TM 9-2900
Qualifications in arms and ammunition training allowances	AR 775-10
Range regulations for firing ammunition in time of peace	AR 750-10
Unsafe ammunition	OFSB 3-11

b. Ammunition, special types.

Field artillery and field mortar ammunition	OFSB 3-3
60-mm mortar M2	FM 23-85
81-mm mortar M1	FM 23-90
Mortar ammunition	TM 9-1935
Seacoast, railway, antiaircraft and field artillery ammunition	OFSB 3-2
Small-arms ammunition	TM 9-1990
Small-arms ammunition	OFSB 3-5

c. Bombs, grenades, and pyrotechnics.

Aircraft bombs and bomb components	OFSB 3-7
Bombs for aircraft	TM 9-1980
Grenades	TM 9-1985
Grenades	OFSB 3-10
Hand grenades	FM 23-30
Military pyrotechnics	TM 9-981

d. Cleaning, preserving, lubricating, and welding materials	TM 9-850

e. Miscellaneous.

Defense against chemical attack	FM 21-40
Inspection of propelling charges and bulk powder	OFSB 3-13
List of publications for training	FM 21-6
Magazine placard	O. O. 5991

Military chemistry and chemical agents	TM 3-215
Military sanitation and first aid	FM 21-10
Ordnance Field Manual	FM 9-5
Ordnance safety manual	O. O. 7224

f. Prescribed regulations.

Administration; posts, camps, and stations	AR 210-10
Fire protection and fire fighting	AR 30-1580
Honors to persons	AR 600-30
List of current pamphlets and changes; distribution	AR 1-10
Lost, destroyed, damaged, or unserviceable property	AR 35-6640
Ordnance field service in time of peace	AR 45-30
Salutes and ceremonies	AR 600-25
Supplies, storage, and issue	AR 700-10
Transportation by commercial means; general	AR 30-905
Transportation of supplies	AR 30-955
Transportation by water of explosives, inflammables, and chemical warfare materials	AR 30-1270

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G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

J. A. ULIO,
Major General,
The Adjutant General.

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ORDNANCE SAFETY MANUAL

REGULATIONS GOVERNING THE MANUFACTURE, STORAGE, LOADING, AND HANDLING OF MILITARY EXPLOSIVES AND AMMUNITION AT ESTABLISHMENTS OF THE ORDNANCE DEPARTMENT, U. S. ARMY

OFFICE OF
CHIEF OF ORDNANCE

December 1, 1941

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WASHINGTON, D. C., *December 1, 1941.*

ORDNANCE SAFETY MANUAL

This Manual supersedes all previous editions of O. O. Form No. 7224.

C. M. WESSON,
Major General,
Chief of Ordnance.

Official:
H. C. MINTON,
Lt. Col., Ord. Dept.,
Executive Assistant.

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PART I

GENERAL REGULATIONS FOR THE MANUFACTURE, LOADING, STORAGE, HANDLING, SHIPPING, SURVEILLANCE, MAINTENANCE, SALVAGE, AND DESTRUCTION OF ALL CLASSES OF MILITARY EXPLOSIVES AND AMMUNITION

SECTION I

INTRODUCTION

1. Purpose.—The purpose of this manual is to acquaint personnel of the Ordnance Department with the characteristics and hazards of explosives and ammunition, and to prescribe rules and regulations, the application of which will reduce the hazards involved in manufacturing, processing, storing, and otherwise handling explosives and ammunition at ordnance establishments.

2. Scope.—*a.* This manual gives general and specific information regarding explosives and ammunition in the stages of manufacture, and under the conditions in which they may exist at ordnance establishments, and prescribes safe methods and practices pertaining thereto. Safety requirements which are outlined herein are the minimum compatible with proper safeguarding of personnel and property. These requirements apply only to establishments under the control of the Chief of Ordnance.

b. Regulations pertaining to the storing, handling, shipping, and maintaining of explosives and ammunition at posts, camps, and stations are set forth in appropriate field and technical manuals.

c. The mandatory requirements of this manual are those in which the terms "will," or "must" are used. All mandatory provisions will be complied with unless the Chief of Ordnance grants specific authority to the contrary. The advisory provisions are those in which "may" or "should" are used. All advisory provisions will be complied with unless exceptions are authorized by the commanding officer of the establishment.

3. General definitions.—*a. Ordnance establishment.*—An establishment under the direct control of the Chief of Ordnance.

b. Explosives.—Chemical compounds, mechanical mixtures, or ammunition commonly used or intended for producing an explosive effect.

c. Hazardous materials.—Explosives, propellants, inflammable substances, and toxic substances.

d. Inflammable substances.—Inflammable liquids are those which give off inflammable vapors at or below a temperature of 80° F. Inflammable solids are those (other than explosives) which under conditions incident to handling, storage, or transportation are likely to cause fires.

e. Ammunition.—All ammunition or loaded ammunition components of the types issued to troops, including pyrotechnic signals, saluting charges, and other similar materials.

f. Chemical ammunition.—The term "chemical ammunition" as used herein applies to all chemical ammunition except that used exclusively by Chemical Warfare troops.

g. Magazine.—Any structure used for the storage of explosives or ammunition. Magazines such as the older types of ammunition magazines, explosives magazines, and primer and fuze magazines are designated "above ground" magazines, as distinguished from the newer igloo type magazines.

h. Explosive area.—Any area in which explosives or ammunition are manufactured, stored, processed, or otherwise handled.

i. Magazine area.—An area specifically designated and set aside for the storage of explosives or ammunition.

j. Operating building.—Any structure, except a magazine, in which operations pertaining to manufacturing, processing, packing, or shipping, explosives or ammunition are performed.

k. Auxiliary building.—Any nonoperating building serving operating buildings, lines, or plants. Examples of auxiliary building are power plants, service magazines, and change houses.

l. Service magazine.—Any magazine used for the storage of a limited supply of explosives, ammunition, or ammunition components in an operating building or line.

m. Line.—A succession of operating and auxiliary buildings used for the production of one group of ammunition or explosives.

n. Group.—A group is a class of ammunition or components which from a loading consideration are sufficiently similar to use facility requirements interchangeably.

o. Plant.—One or more lines together with the necessary utilities and buildings for shops, storage, administration, and other activities.

p. Surveillance.—The observation, inspection, investigation, and test of ammunition and explosives for determining condition.

q. Maintenance.—The maintaining of stocks on hand in serviceable condition and ready for immediate issue and use.

r. Reconditioning.—Current maintenance operations such as removing rust, repainting, remarking, repairing, and repacking.

s. Renovation.—Those maintenance operations necessary to restore to a serviceable condition that which has deteriorated and which cannot be made serviceable by reconditioning.

4. Data used.—Among the data and sources of information considered in the preparation of this manual are the following:

a. The American Table of Distances.

b. State laws pertaining to explosives and ammunition.

c. House Document 199, Seventieth Congress.

d. War Department Bulletin No. 27, 1928.

e. Pamphlets and regulations of the Bureau of Explosives of the American Railway Association.

f. Interstate Commerce Commission regulations.

g. Sympathetic detonation tests of high explosives shell, Technical Staff Test Program 1922–120.

h. Reports of fires and explosions involving explosives and ammunition on file in the Office of the Chief of Ordnance.

i. Accepted codes and standards.

SECTION II

GENERAL SAFETY REGULATIONS

5. General.—*a.* These regulations are general in nature. Contingencies not covered will require the exercise of discretion and judgment in complying with the requirements of this manual.

b. Existing establishments at which magazines, loading buildings or other facilities and installations do not comply with safety regulations published after their construction, may be exempted from the new requirements of this manual if such action is specifically authorized by the Chief of Ordnance. However, further modifications or alterations to such installations will comply with the latest safety requirements.

6. Responsibilities for safety.—*a.* The Chief of Ordnance exercises general supervision over the safety of ordnance establishments. He prescribes general and certain special safety regulations to be applied in manufacturing, loading, storing, handling, shipping, and maintaining explosives and ammunition.

b. The commanding officer of an ordnance establishment is solely responsible to the Chief of Ordnance for the safety of his establishment. He will enforce the mandatory provisions of this manual and will be guided by the advisory provisions. He will prescribe and enforce such additional safety regulations as may be necessary to meet local conditions not covered by these regulations. He will make a specific written report of any mandatory requirement in these regulations which he may consider impossible of application at his establishment. When, in his opinion, conditions of storage are such that a single fire or explosion endangers large quantities of explosives or ammunition by progressive action from magazine to magazine, a report with recommendations for corrective action will be made to the Chief of Ordnance. Refer to paragraph 24*d* (2) (*d*).

c. At each establishment, a safety officer will be appointed by the commanding officer. The safety officer should be the supervisor of safety at the establishment, and is responsible to the commanding officer for the enforcement of all safety regulations and standards, but has no authority to waive or alter any of the provisions of this manual. In establishments where there is a need for professional safety services because of size or nature of operations, a safety engineer will be employed.

d. A fire marshall will be appointed by the commanding officer at all ordnance establishments. He should be responsible for the proper functioning of the fire-fighting organization of the establishment. He should conduct inspections to insure that all fire-fighting equipment is in proper condition, and that the fire-fighting organization functions properly. Under the commanding officer he normally should be the head of the fire-fighting organization.

e. Trained employees who have positions of authority and responsibility should be held responsible not only for the specific

duties of their position but also for the enforcement of regulations and for vigilance in detecting any dangerous conditions or practices within their purview and for reporting same to their immediate superiors.

7. General safety regulations.—*a.* The following general safety regulations will be enforced at all ordnance establishments:

(1) *Aisles and exits.*—During operating hours, aisles and safety exits will not be blocked, and doors must not be fastened with any locks other than antipanic catches, or other quick-acting fastening devices.

(2) *Authorized entry.*—(*a*) No unauthorized person will be permitted to enter or remain in any magazine or explosive area.

(*b*) Employees will be allowed in explosives buildings only at such times as required by their duties. They will be required to enter and leave the explosives area at designated points.

(3) *Clothing.*—Clothing not worn during working hours will be placed in designated locations only.

(4) *Electrical storms.*—Work on hazardous materials will be suspended during electrical storms, and the employees concerned will withdraw to designated buildings, except that personnel engaged in operations with explosives must remain at their stations until the material and equipment on which they are working may be left in a safe condition.

(5) *Electrical equipment.*—Employees will not make changes in, or tamper with electrical equipment. All repairs and changes will be made by the persons authorized to do this work.

(6) *Explosives handling.*—Explosives or hazardous materials, whether in containers, in bulk, or loaded into projectiles or components will not be handled roughly, thrown about, tumbled over the floor or over other containers, dragged or pushed along the floor. They will be handled carefully to prevent shock or friction which may cause a fire or an explosion.

(7) *Fire drills.*—All employees working in combustible buildings, in hazardous locations, or buildings containing inflammables are required to participate in such fire drills as may be prescribed by local authorities. A siren or similar device will be installed at each ordnance establishment to warn all employees in the event of fire.

(8) *Fire-fighting apparatus.*—Fire-fighting apparatus will not be used for purposes other than fire fighting except by order of the commanding officer.

(9) *Fire prevention.*—All measures possible for the prevention and control of fires will be exercised in explosives areas and in areas immediately adjacent to them. The ground around all above-ground magazines and buildings will be kept as free as practicable from leaves, long grass, brush, debris, or anything which may increase fire hazards.

(10) *Fire protection.*—Explosives areas will be protected by adequate fire-fighting facilities and trained personnel.

(11) *First-aid kits.*—First-aid kits will be made available at all locations, where explosives are manufactured, loaded, stored, shipped, or handled.

(12) *First-aid treatment.*—First-aid treatment will be applied in all cases of injury no matter how slight.

(13) *Forbidden objects.*—Employees who are required to wear special clothing must not carry keys, coins, knives, or any other foreign object of any kind during the time they are in operating buildings.

(14) *Guards.*—Explosives areas will be guarded adequately at all times.

(15) *Housekeeping.*—All buildings and magazines in which there are explosives or ammunition will be kept clean. Waste paper, oil rags, or other inflammable waste materials will be placed in receptacles outside the buildings.

(16) *Hunting.*—Hunting will not be permitted in explosives areas.

(17) *Injury reports.*—(*a*) Employees will report to their immediate superiors all personal injuries however slight.

(*b*) Report of injuries at ordnance establishments will be submitted to the Chief of Ordnance as prescribed in applicable safety bulletins.

(18) *Laundering.*—(*a*) Laundering of special clothing will be done at the plant under the supervision of plant authorities.

(*b*) Uniforms and special clothing will be laundered according to schedules based on the toxicity of the material in which they are used.

(19) *Lights.*—Temporary or extension lights for use in magazines or buildings containing explosives or ammunition must be approved by the commanding officer and must conform with the requirements covered in paragraph 10*c*.

(20) *Locking of doors.*—(*a*) Magazine doors and shutters will be locked securely when employees are not in attendance in the magazine or in the immediate vicinity.

(*b*) When explosives or ammunition are left overnight in cars or other conveyances, the doors must be locked securely, except in the case of railway cars which have been sealed for commercial transit.

(21) *Locomotives.*—All locomotives, cranes, and other rail vehicles used in or near magazines or areas which contain explosives or ammunition will be of such a type or so equipped that they cannot set or communicate fires.

(22) *Lunches.*—Lunches will be eaten only in designated places, preferably change houses, and must not be eaten in rooms where explosives are present.

(23) *Machinery.*—(*a*) Daily on beginning work employees must inspect the machinery under their charge. Employees will be responsible for the safe operation of their machines.

(*b*) If machinery or equipment is out of order, gives indications of improper operation, or if foreign substances are observed in process machinery, work must be stopped on the equipment in question until the cause of the condition or hazard has been removed.

(24) *Machinery testing.*—After repairs have been made to machinery or equipment it must be tested thoroughly and all safety appliances replaced before operations are resumed.

(25) *Matches.*—No person will be allowed to take matches, lighters, or other fire, flame, or spark-producing devices into any magazine area or explosives area except by written authority of the commanding officer.

(26) *Mechanical guards.*—Mechanical guards, railings, ladders, or safety appliances of any other kind will not be removed by employees except for repairs or cleaning. Machines will not be used until such safety equipment has been replaced.

(27) *New employees.*—New employees will be impressed with the fact that their safety as well as that of others depends on the intelligence and care exercised by themselves and their fellow workers.

(28) *Operations in storage buildings.*—No operations in which hazardous materials are involved will be permitted in any storage building except those operations incident to storage. This requirement does not prohibit stencilling containers, or restencilling them in magazines or platforms. No open containers of inflammable liquids for stencilling, or any other purpose will be permitted in or around magazines.

(29) *Personnel.*—All applicants for employment must be given mental and physical examinations. The commanding officer will be responsible for the character of the personnel employed. Care will be taken that no mentally unsound persons are engaged, and that all nondisqualifying physical defects are entered in the record of physical examination.

(30) *Posting.*—All areas in which explosives and ammunition are stored will be posted to show that explosives are stored therein and to prohibit trespassing, hunting, and smoking. These signs will not be attached directly to a magazine or posted so that a rifle bullet fired at them may penetrate a magazine. Signs of standard size and color should be used, for which specifications and drawings will be furnished by the Chief of Ordnance.

(31) *Protective equipment.*—(*a*) Appropriate protective equipment will be made available to all personnel whose duties require its use, and its proper use will be required.

(*b*) Approved goggles, safety shields, or safety spectacles must be worn when employees perform any work in which there is danger of eye injury.

(32) *Placards.*—(*a*) Placard orders limiting the number of men and the amount of explosives, or ammunition in operating buildings or service magazines will be posted in all cases.

(*b*) The foreman or other specially designated persons will be responsible that explosives limits and personnel limits appearing on placard orders are not exceeded.

(*c*) Operations will be stopped in any room or building when for any reason the number of persons authorized by placard orders is exceeded.

(33) *Power.*—When a continuous supply of power is required to prevent the possibility of fires and explosions in any explosives operations, an alternate supply of power will be provided for such critical operations.

(34) *Railways.*—Railroad lines serving explosives storage or operating areas should provide for two-way exit by rail, of all cars containing explosives or inflammable materials.

(35) *Railroad crossing.*—Prominent crossing signs must be displayed on each side of all railroad crossings. Opening between the rails must be graded at crossings.

(36) *Repairs.*—(*a*) Repairs to buildings or equipment must be made by authorized and competent artisan. Surroundings must be inspected for traces of explosives remaining in concealed cracks or under flooring or fittings, before and after repairs to explosives operating buildings are completed.

(*b*) Repairs, construction work or experiments should not be undertaken in an area until the foreman concerned has been notified.

(37) *Roads.*—Road system serving magazines, or explosives operating buildings should be so arranged that trucks carrying explosives will not be isolated on dead end roads in case of fire or explosion.

(38) *Safety equipment.*—Employees must not enter buildings or tanks in which there is an excess of acid fumes or vapors unless they wear suitable protective equipment and have attached to them lifelines controlled by another employee outside the tank or building.

(39) *Safety shoes.*—(*a*) Explosives operator's safety shoes will be worn in all explosives areas when required by this manual.

(*b*) Before an employee enters any magazine or building in which explosives are stored or processed, shoes will be cleaned carefully of all mud, grit or other foreign material.

(40) *Sanitation.*—Change rooms, lockers, drinking fountains, washrooms and toilet facilities will be provided in sufficient quantities to provide safe and healthful working conditions.

(41) *Searches.*—Frequent searches will be made for forbidden articles. These searches should include all personal property.

(42) *Smoking.*—(*a*) Smoking will be prohibited in buildings or in the vicinity of buildings containing explosives, ammunition, or other hazardous material. Smoking areas will be designated and strictly regulated by the commanding officer.

(*b*) Smoking in clothing which has been contaminated by explosives is prohibited.

(*c*) Areas designated by the commanding officer for smoking will be furnished with electric lighters only. Matches and portable lighters will be prohibited.

(43) *Static.*—In all explosives operations provisions will be made, insofar as practicable, for neutralizing, eliminating or grounding charges of static electricity.

(44) *Tools.*—(*a*) Safety tools will be used in explosives areas when required by this manual.

(*b*) Tools used in repair work in buildings containing explosives or used in explosives operations must be checked in before beginning work and checked out at its completion.

(45) *Training.*—(*a*) Employees will be trained under the direct supervision of foremen or experienced workmen until they are competent to perform safely the work assigned to them. The location and use of first-aid kits, fire-fighting apparatus, and exits from buildings and areas will be carefully explained.

(*b*) All employees will be supplied with extracts of the important regulations and essential rules concerning the station, preferably arranged in the form of a small booklet. These regulations should include not only general regulations but specific regulations which apply to the particular establishment.

(*c*) Guards, electricians, carpenters, and others who are not regularly employed in handling explosives and ammunition but who may occasionally come in contact with such materials will have the dangers and the possible causes of fires and explosions carefully explained to them.

(46) *Transportation.*—(*a*) The carrying of hazardous materials on locomotives, or on other vehicles not authorized by the commanding officer, is prohibited.

(*b*) Before any railway car containing explosives or ammunition is moved the car doors will be closed.

(*c*) If, during emergencies it is necessary for locomotives which do not comply with the provisions of paragraph 7*a* (21) to pass buildings in which explosives or ammunition are stored, or in which explosives operations are in progress, the doors, windows, and other openings of the building on the sides adjacent to the track will be closed while such locomotives are passing.

(*d*) Locomotives must not remain in front of buildings containing explosives or hazardous materials for a greater time than is necessary to spot cars for loading or unloading purposes.

(*e*) Trucks used in the transportation of hazardous materials or explosives must be kept in good operating condition. The proper maintenance and inspection of such vehicles will be prescribed by the commanding officer.

(*f*) Trucks or other vehicles loaded with hazardous materials must not stop at any point where a fire may be burning, including blacksmith shop, forge, welding plant, burning ground, or locomotive. A truck so loaded will not be left unguarded.

(47) *Unsafe conditions.*—(*a*) Any and all unsafe conditions in or around magazines or manufacturing buildings or explosives areas will be immediately corrected if possible or promptly reported by employees to their immediate superior.

(*b*) In extra hazardous loading or handling operations, one man will not be permitted to work alone, or in a location where assistance from a fellow employee cannot be given immediately in the event of an accident.

8. Safety rules for foremen.—*a*. The word "foreman" in this manual is used to indicate any person who is in a supervisory capacity.

(1) The foreman has no authority to waive or to alter safety regulations, or to permit their violation by others.

(2) All foremen will familiarize themselves with the provisions of this material.

(3) The foreman should explain and invite the attention of all employees under his immediate supervision to standard safety regulations, stress the necessity of all employees living up to the spirit, as well as the letter, of safety regulations for their own sake as well as for the sake of others. He should explain as far as possible the character of the explosives, the precautions to be followed, and the hazards due to fire and explosions if safety requirements are not carried out.

(4) He should supervise the instruction and training of employees, either directly or through experienced operators, until he is satisfied that the employees can work alone. This instruction should include the means of exit from buildings and areas, the location of shelters and bombproofs, first-aid kits, fire-fighting apparatus, showers, plunges, neutralizing solutions, and the methods of operating the same.

(5) He should report to his immediate superior cases of all employees who, in his opinion, are not fitted for the work to which they have been assigned.

(6) He should satisfy himself as to the identity of any persons entering or approaching the buildings, and their authority to enter or remain in a building or area in his charge. He has the authority, and should exercise the right to eject any person whose presence or actions are prejudicial to safety.

(7) He should be responsible for the enforcement of placard orders. When the total number of persons, including operators, foremen, truckmen, inspectors, repair men, visitors, and Government representatives, exceeds the number permitted in the room, it is the duty of the foreman to cease operations and

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invite the attention of the people not regularly employed in the building to the excess number.

If the notice is not effective in reducing the number of persons in the room or building to the number permitted, he should withdraw his crew, until they may return to work in accordance with the safety regulations.

(8) When the amount of explosives in a room or building exceeds the amount permitted, the foreman should have the amount in excess removed, or cease operations during the time the excess remains in the building.

(9) He should require permissible tools, not in use, to be in place on a tool board or holder. In case of the loss of tools in manufacturing process rooms or buildings, operations must be stopped until he is satisfied that the lost tool cannot become the source of additional hazard. Also he should see that the regulations regarding safety uniforms and safety shoes are observed.

(10) The foreman of each shift or crew should be responsible for the cleanliness of the building. He should maintain all safeguards, prevent the blocking of safety exits and aisles and enforce all safety regulations applying to the employees under his supervision.

(11) He should not permit major repairs or changes in any building, machinery or equipment in buildings containing hazardous materials, except in accordance with specific instructions of the commanding officer. He should enforce the safety standards in buildings under repair in his area, although the repair force may not be under his orders.

(12) At the close of work he should satisfy himself before leaving, that all conditions in his room, building, or area with regard to a shutdown, comply with orders. When not relieved by a shift, he should see that windows and doors are closed and locked, and that any master power or light switches outside of the building are opened. When his shift is being relieved by an incoming shift, he should make a complete report to his relief of any equipment requiring immediate attention.

(13) He should inspect and maintain, or cause to be maintained, stocks of goggles, gloves, gauntlets, gas masks, aprons, helmets, safety uniforms, safety shoes, and such other safety implements, accessories, and appliances as are required on the work with which he is charged.

(14) He should bring to the attention of his immediate superior all places where railings, footboards, lights, guards, hoods, automatic stops, or safety appliances are required; also all places at which sprays, showers, plunges, shelters, or bombproofs are desirable.

(15) He should report to his immediate superior all cases, where, in his opinion, the employees lack sufficient room for the performance of their duties or where sufficient ventilation, heat, light, or other necessities are not being supplied.

(16) He should forward to his immediate superior all requests, suggestions, and complaints made to him, together with such comments as he may have, with regard to safety standards. These should be in writing and should be a part of the safety records of the plant.

9. Safety signs and placards.—*a.* All operating rooms containing explosives will have posted in a conspicuous place a placard order stating the maximum amount of explosives, and the maximum number of persons permitted in the room at any one time. In addition, such other placards as may be needed to set forth important local regulations should be provided.

10. Safety tools.—Safety tools are tools constructed of wood and other nonsparking substances, or of bronze, lead, beryllium alloys, or other metals having low sparking characteristics, and which, under normal conditions of use, will not produce sparks.

11. Special clothing.—*a.* When manufacturing or handling some hazardous materials, special clothing is required. Safety uniforms and special clothing will be worn as prescribed by the commanding officer. The suits for men and women must have no metal buttons. They should have no pockets except skeleton pockets. Woolen clothing is recommended for men engaged in handling acids. When safety uniforms are required, a complete change of clothing is recommended. Street clothes should not be worn at work, and the clothes which are worn at work should not be taken from the plant unless they are in safe condition.

b. The design of clothes should be made to fit requirements. In the handling of some materials used in the manufacture of explosives, the slight friction caused by clothes which fit tightly at the waistband, belt, or around the neck is sufficient to cause irritation and possible poisoning of the employee.

c. Employees who are required to wear safety uniforms must not carry keys, coins, knives, or metal of any kind during the time they are in operating buildings.

d. Special conditions require special footgear. No general type of footgear can be used universally. Where there is fine explosives dust, as in a smokeless powder blender or black powder loading plant, and where there is danger of igniting explosives vapors by static electricity, as in the graining room of a smokeless powder factory, personnel must not be insulated from the floor. Hence, footgear with insulating soles is forbidden. They must contain no exposed metal or metal which may become exposed through wear. Footgear with composition soles meeting the general requirements stated above may be worn when approved by the commanding officer.

12. First aid.—*a.* First-aid kits will be installed in all parts of the plant in which persons are regularly employed and which in the opinion of the surgeon are too remotely located for the prompt and efficient rendering of first-aid treatment by hospital or dispensary personnel. Workers not regularly assigned to specific locations, such as magazine area personnel, will be provided with portable first-aid kits under such rules and regulations as may be prescribed by the surgeon.

b. In addition to first-aid kits, the need for stretchers, blankets, safety showers, gas masks, and mine rescue units should be determined by the surgeon and such equipment as is necessary should be regularly kept in convenient locations known to the personnel concerned.

c. The surgeon will make or cause to be made such inspections as may be necessary to insure that all first-aid kits, blankets, and stretchers, and other items of first-aid equipment are maintained in good condition.

d. For every 50 persons or less at work in plants manufacturing or using hazardous materials, there should be present at all times at least 2 persons who are competent to apply first-aid remedies and who are trained in methods of resuscitation. Usually, arrangements may be made locally for proper first-aid training of selected employees. These arrangements should be made either directly with American Red Cross Association officials, or through the office of the post surgeon, at the discretion of the commanding officer.

e. Victims of attacks of cramps, coughing spells, nausea, or sickness due to exposure to acid fumes, vapors, or asphyxiating gases must be treated immediately by a physician. Responsibility for compliance with this rule lies with the foreman.

13. Sanitation.—*a.* The lack of sanitation in any establishment affects the alertness of workers. Accidents frequently have been traced to unsatisfactory conditions and to unwholesome and unhygienic practices. Observation of certain standards tends to eliminate accidents, discomforts, and industrial poisoning.

b. A sufficient number of adequate change rooms should be provided in all areas where changes of clothing are required.

c. Distribution of sanitary fixtures depends on local conditions. Shower baths, wash basins, and toilets, should be provided as required. The plant should have an efficient sewer and waste disposal system to which all sanitary fixtures and appliances are connected.

d. Drinking fountains in selected locations should be provided as required. These fountains must comply with modern sanitary standards.

e. Dispensers or other means for supplying salt tablets should be provided near drinking fountains serving locations in which the nature of operations might result in heat exhaustion.

f. Industrial wastes will not be disposed of through sanitary sewers, septic tanks, or sanitary filter beds. Waste water from laundries where explosives operators' clothing is washed or other waste water containing explosives will be disposed of separately; and settling tanks or pits will be provided in all cases in which the quantities of explosives in the waste water may constitute a hazard from settling or by contaminating soil or water.

14. Industrial health hazards.—A great many manufacturing operations involving the handling of industrial solvents or certain toxic explosives present serious hazards to the health of operators. Examples are the toxic effect of fumes from such materials as carbontetrachloride, molten TNT, and the allergic effect of these or similar materials upon certain people. The presence of industrial health hazards should be determined by safety engineers working in cooperation with appropriate medical authorities—the post surgeon, if available. First-aid stations will render first-aid treatment. Any required subsequent treatment is covered by regulations of the Compensation Commission.

15. **Guards.**—*a.* As guards at ordnance establishments may consist of military personnel, civilians, or both, and as there are other local conditions affecting guard protection, not common to all establishments, the general subject "Guard protection for Ordnance Establishments" is covered by Army Regulations and administrative orders of the Chief of Ordnance.

b. Since there are certain special safety precautions which must be observed in guarding stores of explosives and ammunition, it is the purpose of this section to set forth special safety regulations which will be strictly enforced and obeyed in guarding stores of explosives and ammunition at ordnance establishments.

16. **Special guard regulations for explosives storage.**—*a.* Magazines and areas in which there are explosives and ammunition will be guarded adequately at all times. If employees working in a magazine or magazine area are utilized for this purpose their responsibilities relative to guard duty must be clearly defined.

b. Guards and others in charge of explosives and ammunition will be thoroughly instructed in the hazards due to fire and explosions and the safety precautions to be taken.

c. In making inspections, special attention will be paid to guards assigned to protect stores of explosives and ammunition to insure that they thoroughly understand their duties and are performing them properly.

d. Guards will make a prompt report to the commanding officer or his duly authorized representative of the following:

(1) Any unusual occurrence in or near a magazine area.

(2) Grass or forest fires in areas adjacent to the magazine area.

(3) Dangerous practices of employees working in magazines or explosives areas, such as smoking, unauthorized use of fire equipment, and tampering with ammunition or electrical equipment.

(4) Unlocked magazine doors and shutters, defective telephone and electric wires, and openings in the fences surrounding the magazines.

e. Hunters either inside or outside a magazine area who are found using firearms in a manner which may endanger military stores will be reported to the commanding officer, who will take such action as is necessary to punish the offenders.

f. Except in special cases guards protecting explosives or ammunition will not be armed with rifles. A bullet penetrating a magazine wall may cause a serious fire or explosion.

g. All entrances to magazine areas protected by nonclimbable fences will be locked securely unless guards are stationed there. Special precautions will be taken to guard areas which are not protected by a suitable fence.

h. In case of fire, alarms will be given with the greatest possible speed so that action may start instantly. Serious fires and explosions have been avoided by prompt action of the fire-fighting forces. After giving the alarm, guards will exert every effort to hold the fire under control until the fire-fighting forces arrive, except that if a fire occurs in a closed magazine, they will not attempt to enter the magazine.

i. Trespassers who are observed within a magazine or explosives area will be apprehended, and turned over to the commanding officer.

17. **Airspace reservations, reserved areas and restricted areas.**—The designation at ordnance establishments of airspace reservations, reserved areas, and restricted areas are included in applicable Army regulations. Such additional general instructions concerning these areas as may be necessary will be published in the form of ordnance safety bulletins.

Section III

FIRE PROTECTION

18. **General.**—*a.* Many of the fires involving explosives and ammunition are preventable, for the causes have been well established and can therefore be anticipated and controlled or eliminated. It is the duty of all concerned in the handling of explosives and ammunition to study the causes of fires and thoroughly inform themselves of the safety precautions that must be taken to prevent them.

b. As firefighting facilities, organizations, and methods vary quite widely at the various ordnance establishments and are affected by local conditions, the general subject "Fire Prevention and Fire Fighting" is covered by Army Regulations, and administrative orders of the Chief of Ordnance.

c. Many of the general safety regulations are primarily for the prevention of fires. In addition thereto, certain special fire-preventive regulations are necessary and are contained in this section, being preceded by a brief discussion of the causes of fires, the purpose of which is to explain and emphasize the importance of all safety and fire-prevention measures set forth in this manual.

d. This section also contains regulations and advice as to fire-fighting facilities, organizations, and methods insofar as these differ from those ordinarily employed when stores of explosives and ammunition are not involved.

19. Causes of fires.—*a.* Fires in magazines and magazine areas in which explosives and ammunition are stored may result from several causes, of which the following are the most common:

(1) *Dry grass, leaves, and underbrush.*—These may be ignited by sparks from locomotives, by smoking, or the careless use of matches and camp fires. Such fires often originate in areas adjacent to military establishments not under the direct control of the commanding officer. If they are not detected and controlled, they may spread quickly and become uncontrollable.

(2) *Deteriorated explosives and ammunition.*—Explosives and ammunition deteriorate in storage. Normally, this deterioration occurs at such a slow rate that most explosives and ammunition remain serviceable for many years. However, under unfavorable storage conditions where the ammunition is subjected to abnormally high temperatures (above 80° F.) or exposed to moisture for a prolonged period, the rate of deterioration is greatly accelerated. Practically all explosives and ammunition give off heat as they deteriorate but where the rate of deterioration is slow the heat thus generated is dissipated by conduction or radiation and no noticeable rise in temperature takes place, but, when deterioration becomes rapid, heat may be generated so fast that it cannot be thus dissipated and the temperature rises. This accelerates the deterioration still more until finally the temperature may become high enough to cause the explosive or ammunition to burst into flame and in certain cases where the explosive or ammunition is confined an explosion or detonation may result.

(3) *Repacking, renovation, and salvage operations not properly supervised and conducted in accordance with recognized safety standards.*—The most common sources of trouble are excessive quantities of powder and loose explosives; accumulation of waste paper, broken boxes, etc.; and failure to properly provide the barricades and fire breaks necessary to prevent the spread of fire from one operation to another.

(4) *Carelessness or violation of regulations.*—Untrained employees or other persons may cause fires by smoking, or striking matches in forbidden areas and buildings, or by tampering with explosives or ammunition, particularly grenades, fuzes, etc.

(5) *Failure to observe safety precautions.*—Failure to understand and observe carefully the safety precautions prescribed by these regulations for destroying explosives and ammunition. The most frequent sources of trouble are flying fragments which cause grass fires or explode piles of explosives and ammunition awaiting destruction.

(6) *Sparks.*—These may be caused by striking iron or steel nails or metal containers with iron or steel tools, or by nails in shoes striking flint, pebbles, sand grains, or nails in the floor. Such sparks, small as they are, have caused disastrous explosions of black powder or the dust of other explosives which ignite easily. They are the basis for requirements in this manual for non-sparking tools, and safety shoes.

(7) *Static electricity.*—A considerable charge of electricity may accumulate on smokeless powder and upon the body of an operator during the handling operations. When a person so charged approaches powder or explosives, a spark may jump between him and the powder or explosives and ignite them. Machine belts also frequently produce static electricity, especially if the drive is short and the belt crossed. When possible, the scoop shovels, and other tools, used in handling smokeless powder should be attached to a ground wire. This prevents any accumulation of static electricity upon the body of an operator, and it also grounds to a large extent the electricity produced in the movement of the powder grains. Static generated by moving belts may be eliminated by the use of conductive rubber belts, or it can be collected and grounded without sparking, by means of a collector constructed of a brass or copper bar or pipe to which is soldered a piece of fine copper or brass wire screen 2 to 6 inches

in width and approximately the length of the bar. The outside edge of the wire screen of the collector is located near the moving belt and the bar is suitably grounded. A person generating static electricity upon his body during handling operations in a building containing ammunition or explosives should go occasionally to the door and touch a suitable ground to remove the charge. The efficacy of humidification for the reduction of static is a controversial subject. Explosions of vapor-laden atmospheres have occurred in locations in which relative humidities as high as 65 percent have been artificially induced. Safety bulletins covering the subject of static control will be issued from time to time as the subject becomes clarified.

(8) Failure to properly safeguard heating appliances, such as torches and furnaces used in making repairs to magazine roofs and magazines.

(9) Lightning striking buildings, trees, or other objects in or near explosive areas.

(10) Electric transmission lines, blown down or in contact with combustible materials.

(11) Lack of a proper muffler, or the use of a muffler cutout, on gasoline-driven vehicles.

20. Special fire-prevention rules.—*a.* Fire prevention is of the utmost importance because of the difficulties encountered in controlling fires involving explosives and ammunition. The special fire-prevention rules set forth below are minimum requirements for Ordnance establishments storing explosives and ammunition. They will be supplemented by such additional rules as the commanding officer deems necessary to secure adequate protection against fires at his establishment.

(1) During the absence of the commanding officer, there will be present at the establishment a competent person to act for him in case of fire or other emergency. This person preferably should be a commissioned officer, but may be a warrant officer, noncommissioned officer, or civilian.

(2) The duties of guards, firemen, military personnel, and others will be so arranged that an adequate fire-fighting force is available at all times.

(3) Fire-fighting forces will be instructed thoroughly in the hazards due to fire and explosion, the safety precautions to be taken, and the means and methods to be used in preventing and fighting fires.

(4) Fire drills and inspections will be conducted carefully to insure that the fire-fighting forces understand their duties and that fire-fighting equipment functions dependably under actual working conditions. Hose not tested at working pressures frequently bursts when most needed.

(5) The duties of electricians, engineers, plumbers, and other workmen who are not regular members of the fire department, but who may be required to start fire pumps, cutout electric power lines, etc., will be carefully defined.

(6) All fire-fighting equipment, especially hand fire extinguishers, water barrels and buckets, and the supplies of auxiliary equipment, such as gunny sacks and brooms, will be inspected regularly as prescribed by the commanding officer. Any deficiencies reported will be corrected promptly.

(7) Repacking, renovation, salvage, and all operations involving the handling of explosives and ammunition, will be inspected regularly as prescribed by the commanding officer to see that the necessary fire-fighting equipment is present and in good working order.

(8) When explosives and ammunition are being handled, or work is being done in the immediate vicinity of such stores, there will be present, ready for immediate use, two chemical or other type hand fire extinguishers.

(9) To combat grass or forest fires in or near magazine areas, there will be maintained at suitable locations an adequate supply of gunny sacks, brooms, rakes, hoes, or other similar equipment. It is good practice to provide a railway tank car, truck, or trailer equipped with a pump and fire hose for fighting fires in a magazine area. This equipment will be inspected regularly and protected against theft or unauthorized use.

(10) Vegetation in the form of grass, undergrowth, weeds, etc., which is or may become a fire hazard, will be controlled by mowing, plowing, cutting, or, in calm weather and under adequate safeguards, by burning. Burning will not be permitted within the 50-foot space specified in the paragraph below, and brush, grass, wood, etc., in piles, will not be burned within 200 feet of a magazine.

(11) A firebreak at least 50 feet wide and as free as practicable from combustible material, will be maintained around each above-ground magazine. The earth adjacent to, and extending over igloo magazines will not be cleared of vegetation other than dry debris.

(12) The vegetation on and along railroad tracks will be controlled so that they will act as firebreaks.

(13) In addition to those specified above, firebreaks around the entire magazine area and at other places within the magazine area will be maintained wherever necessary.

(14) Coal-burning locomotives used in or near magazine areas will be fitted with efficient spark arresters, and openings near the fire box will be protected and double ash pans provided so that sparks will not be blown out and thus cause grass fires.

(15) Keys to gates, magazines, and other buildings, which fire-fighting forces may enter, will be kept readily available at such places as the commanding officer may designate.

(16) Portable lights satisfying the requirements of paragraph 100e may be used in the presence of explosives or inflammable vapors.

(17) (*a*) Water lines should be divided into sections by cut-off valves in order that in the event of a breakage in one location, the damaged section can be cut off from the remainder of the system. Water mains should not be located under railroads or roads which are used for conveying large quantities of explosives and ammunition, as a detonation of a large quantity of explosives over a water main may cause the loss of all the water in the system. Where pipe lines are crossed by roads or railroads, no cars or trucks loaded with explosives or ammunition will be permitted to remain over the water lines longer than is necessary to pass from one side to the other. Lateral lines are not considered in this class. The latter should be provided with a shut-off valve not less than 50 feet from buildings.

(*b*) In the layout of new operating areas in explosives manufacturing, ammunition loading plants and of new renovation plants at depots, protective measures against the spread of fires or explosions will be included as follows: All fire hydrants should be supplied by feed lines or laterals so arranged that water can be supplied from either direction. Sufficient cut-offs will be provided to permit a supply of water to any portion of the plant, even though the water supply from one direction is broken. Particular attention will be paid to lines crossed by explosives-carrying roads and railroads with a view to keeping such crossings at a minimum and protecting them by sufficient cut-off valves.

(18) Special precautions will be taken to avoid ignition of explosives or vapors by the exhausts of automotive vehicles. The doors through which a shipment is to be passed will be kept closed while the engine of the vehicle is running and will not be opened until after the motor has been switched off or the vehicle has left the vicinity.

(19) Fires of either accidental or incendiary origin in parked automobiles may result in trails of burning fuel which may spread the fire to adjacent cars or buildings. Under certain conditions, such fires may result in extensive damage. Parking within ordnance stations should be so controlled as to minimize these fire hazards.

21. Fire-fighting facilities.—*a*. A fire involving explosives or ammunition may result in an intense conflagration or an explosion. Means for immediately attacking the first small blaze detected in a magazine or magazine area are vital, and reliance often must be placed upon hand equipment which can be maintained ready for immediate use. The following types of fire-fighting equipment may, under certain conditions, be used to good advantage and to supplement the regular fire-fighting facilities ordinarily maintained at ordance establishments.

(1) Water barrels and buckets placed at each magazine or at places specified by the commanding officer. If this class of fire-fighting equipment is always maintained so that it can be depended upon in case of fire, it is a valuable fire protection. However, in the summer time, the barrels must be frequently refilled, and in freezing weather, brine must be used. Buckets deteriorate rapidly unless they are painted frequently or protected from the weather, and sometimes they are blown about by wind storms if they are not fastened securely in place. Any devise used for this purpose must be capable of being released at will.

(2) Tank cars, trucks, or trailers filled with water and so located that they are readily available. Such protection, however, cannot be relied upon in freezing weather or when facilities for rapid movement to the scene of a fire are lacking.

22. Fire fighting.—*a*. To combat successfully fires involving explosives and ammunition, it is necessary that the personnel understand thoroughly what a particular kind or class of explosive or ammunition will do when subjected to heat or flame. The sections of this manual which pertain to particular classes and kinds of explosives and ammunition give, in as much detail as possible, what the experience has been with fires in that particular kind or class of material, and also the general safety precautions to be observed in fighting the fire.

b. General instructions which will be followed in combating any fire involving explosives and ammunition are as follows:

(1) When any person discovers smoke coming from a magazine, or other evidence that a magazine is on fire, he will give the alarm as quickly as possible. He will fail in his duty if he attempts to go into the burning building, as there is a possibility that he may be trapped and cannot give the alarm. When any person discovers a grass fire he immediately will give the alarm. If the fire is small, and he is sure that he alone can extinguish it, he will do so at once.

(2) Fire-fighting forces, when they arrive, will attack a grass fire vigorously even when it is close to a magazine.

(3) In case a fire has actually gained headway in a magazine, fire-fighting forces will be directed not to endanger themselves in hopeless efforts to extinguish the fire, but to devote their efforts to saving adjacent buildings.

(4) To safeguard operators, work must be discontinued in buildings containing ammunition or explosives during thunderstorms. Operators are required to report to the bombproofs, shelters, or other locations where they will be safe in the event lightning causes an explosion in a building, except that personnel engaged in operations with explosives must remain at their stations until the material and equipment on which they are working may be left in a safe condition.

Section IV

STORAGE, MAGAZINES AND MAGAZINE AREAS

23. General.—*a.* The general regulations governing the storage of military supplies are set forth in AR 700–10, Storage and Issue. This section contains special regulations applying to the storage of explosives and ammunition at ordnance establishments. Special regulations which apply to storage of explosives at manufacturing establishments are covered in part III.

b. Ordnance ammunition depots and manufacturing arsenals which have the older type of magazines or which store only limited quantities of explosives and ammunition and which cannot comply with the regulations set forth herein, will comply with the spirit of the regulations and endeavor to obtain maximum protection against fire and explosions and to limit deterioration to a minimum.

c. Explosives and ammunition in quantity will not be stored in buildings which are used for other purposes. Neither will they be stored at ordnance establishments in the open without approval from the Chief of Ordnance.

24. Regulations for magazines and magazine areas.—*a.* All explosives and ammunition except small-arms ammunition should be stored preferably in arch type, earth-covered (igloo) magazines. Their use for such storage is required in all future depot construction; and is authorized but not required for operating storage areas in manufacturing and ammunition-loading establishments. (See par. 37.)

b. In order to provide flexibility in storage, igloo magazines will be separated by minimum intervals of 400 feet in all future depot construction; and, if unprotected by barricades at the door ends, they will be uniformly staggered to provide a safety distance of 800 feet extending perpendicular to the front from the door of each magazine, through the interval between the nearest magazines of the next row, to the rear end of the nearest magazine of the second row. Their distance from inhabited buildings, public railways, and public highways will be based on the types of ammunition or explosives to be stored therein.

c. New depot storage areas will comply with the requirements of paragraph 42, Special Area Distances.

d. For storage in magazines other than igloo magazines, any ammunition or explosives may be stored in any suitable magazine. The suitability of a magazine for the storage of any item is governed principally by the following considerations:

(1) The type and amount of material which may be stored in any magazine is directly dependent upon quantity-distance requirements. Magazines will not be loaded in excess of the limits specified in these regulations. However, it is desirable that ad-

vantage be taken of the maximum storage volume available in the magazines.

(2) Chemical ammunition is stored preferably in magazines having concrete floors. The storage of such ammunition in magazines having wooden floors is prohibited.

c. The following are requirements for magazines and magazine areas:

(1) Magazines must be sufficiently remote from inhabited buildings, public railroads, and public highways so that the dangers and risks involved in storing explosives and ammunition are confined almost wholly to the magazine area. The quantity-distance tables of section V are based upon the study of a large number of explosions, and contain complete data on this subject.

(2) (*a*) Administration buildings, quarters, barracks, and general storehouses should be grouped in a safety zone outside the magazine area and at inhabited building distances.

(*b*) In groups of igloo magazines, it is not required that bulk high explosives or ammunition be arranged so that like types or classes are together.

(*c*) In groups of above-ground magazines, magazines containing bulk explosives, magazines containing smokeless powder, magazines containing primers and fuzes, and magazines containing ammunition, each should form definite sections. Each section should be so located that due consideration is given to the hazards and risks involved in storing each class of material. These risks are:

1. The structural damage resulting from the explosion of high explosives. (See par. 37*d*.)

2. The fire hazards of smokeless powder. (See par. 37*a*.)

3. The missile hazard of shell and fuzes. (See par. 27*c*.)

(*d*) *1.* In arranging the storage of hazardous material in above-ground (not concrete igloo-type) magazines, the following general principles should be followed as guides for preventing the spread of damage throughout an entire area, in case of fire or explosion in one part of the area:

a. Smokeless powder or other materials which may become hazardous if the buildings in which they are stored are damaged or demolished, or which may be ignited or exploded by burning or exploding missiles, should be stored at inhabited building distances from high explosives and ammunition magazines.

b. Bulk high explosives or bombs should be stored so they will be protected from missiles which may be thrown from ammunition magazines as a result of explosions. This principle requires a magazine in which bulk high explosive is stored to be at missile distance from a magazine in which ammunition is stored.

c. In applying the principles set forth in subparagraphs *a* and *b* above, magazines laying between areas in which ammunition, high explosives, or smokeless powder are stored, may be used for the storage of such other material as will minimize the danger of fires or explosions progressing from area to area.

2. It should be borne in mind that the probability that one explosion will result in progressive damage increases in proportion to the extent to which these principles are relaxed.

(3) Good roads for use by guards and fire fighters should be provided. Roads for traffic to and from the safety zone should not pass through the magazine area.

(4) Good drainage facilities should be provided in magazine areas, as some explosives and ammunition deteriorate very rapidly in the presence of moisture.

(5) Magazines should be constructed of materials which in the event of an explosion will not form dangerous missles or firebrands.

(6) Magazines should be fireproof unless the hazard is one which permits the use of a frame building. All frame buildings should be covered with fire-resistant material, such as corrugated sheet asbestos.

(7) When wooden floors are used, the finished floor should be laid so as to avoid cracks and crevices where spilled explosives may lodge. Narrow tongued and grooved material, blind nailed, should be used in laying the finished floor.

(8) Construction of a nature which might allow the accumulation of explosives dust must be avoided.

(9) All doors to magazines must be constructed of fire-resistant material, and must be made to fit as tightly as possible to seal the opening.

(10) Magazines usually are not wired for electric lights; but when electric lights are used, the installation shall conform to the requirements of paragraph 169*e*.

f. The maximum quantities of ammunition and explosives authorized at shipping and receiving platforms, and at packing and shipping buildings, will be limited by the distances to the nearest inhabited building, public railway, public highway, operating building, magazine, or other packing, shipping, or receiving building or platform for the classes of explosives or ammunition concerned. Shipping and receiving platforms may be used for packing, crating, and stencilling operations, but will not be used for soldering or renovation operations.

25. Temporary storage in shipping and receiving buildings.—*a.* Ammunition and explosives may, subject to the following limitations, be stored, in accordance with the Loading and Storage Chart of Explosives and Other Dangerous Articles as contained in the Interstate Commerce Commission regulations for the transportation of explosives and other dangerous articles, in buildings specifically designated and used as packing or shipping buildings.

b. Income shipments will not be allowed to accumulate but must be distributed as soon as practicable after receipt.

c. Items for outgoing shipments will not be accumulated prior to receipt of orders covering each specific shipment.

d. Special rooms will be provided for the temporary storage of ammunition and explosives awaiting shipment, and for their preparation for shipment by assembling, crating, marking, etc. These rooms will be separated from each other and from offices and rooms in which inert operations such as the preparation of stencils and packing and crating materials are performed, by substantial dividing walls so constructed that they will act as fire walls. (See par. 44.)

e. Not more than three cars of ammunition or explosives, including both incoming and outgoing cars, will be permitted at a shipping or receiving building, and not more than three loaded cars will be permitted at a building used as a combined shipping and receiving building. In no case shall the total amount of explosives contain in cars and buildings combined exceed that authorized by the intraplant quantity-distance table for the distance to the nearest magazine or operating building. This paragraph applies only to such packing and/or receiving buildings as are used for material stored in accordance with the I. C. C. loading chart, and not in accordance with the storage chart in appendix II. (See par. 45c.)

f. These shipping and receiving buildings must also comply with prescribed safety distances with respect to inhabited buildings, public railways, and public highways, based on the ammunition and explosives in buildings and cars combined.

26. Types of magazine construction.—*a.* Magazines which may be found at ordnance establishments are designated as "explosives magazines," "smokeless powder magazines," etc., but this designation does not limit storage as explained in paragraph 24, above. Following brief descriptions of each type are based on most recent designs. Further descriptions and details of magazines may be obtained from the Chief of Ordnance.

(1) *Concrete, arch-type, earth-covered (igloo) magazines.*—These magazines are intended for the storage of all types of explosives and ammunition except small-arms ammunition. They are 20 feet 1⅛ inches wide and of lengths 41 feet 6 inches, 61 feet 10 inches, and 82 feet 2 inches. They are constructed of concrete foundations, rear walls, front walls, and arch roof. The exterior of the arch ring and exterior of rear wall are covered with membrane waterproofing, and directly against this membrane is deposited a layer of sand; over which is an earth fill. The thickness of the fill is limited to 2 feet above the arch ring.

(2) *Temporary igloo magazines.*—Igloo magazines fabricated from steel and covered with earth have been adopted for emergency use. They are constructed in various sizes by varying the number of sections.

(3) *Explosives magazines.*—These magazines were designed for the storage of bulk explosives, such as black powder, TNT, tetryl, and explosive D. They are 27 feet 6 inches wide and 43 feet 4 inches long and when grouped together in a magazine area are usually spaced 800 feet apart. They are constructed with concrete foundation walls and piers, hollow-tile walls filled with sand, steel frame, and concrete floors covered with spark-proof mastic or equal topping. The double pitched roof supported on steel purlins and trusses, is of corrugated asbestos. The ceiling supported by steel beams from the bottom chords of the trusses is of corrugated asbestos covered with fire resistant insulation such as rock wool, or equal. There are ventilators on the roof and in the foundation walls below the floor. The ventilators are always well screened or baffled to prevent the entrance of sparks. The hollow-tile walls are filled with sand to stop rifle bullets. These magazines were originally designed for the storage of 250,000 pounds of explosives; but with ample aisle space for inspection and shipping, and piles of convenient height, the amount is usually limited to approximately 100,000 pounds.

(4) *Smokeless powder magazines.*—These magazines were designed for the storage of smokeless powder in boxes or in the form of separate loading propelling charges. They are 37 feet 11 inches wide and 110 feet long and when grouped together are usually spaced 300 feet apart. Details of construction are similar to those outlined under explosives magazines. These magazines originally were designed for the storage of 600,000 pounds of powder in boxes. The amount of powder in the form of propelling charges which can be stored in a magazine of this type is usually less than this.

(5) *Primer and fuze magazines.*—These magazines were designed for the storage of primers, primer detonators, adapters and boosters, and fuzes of all types. They are 27 feet 6 inches wide and 43 feet 4 inches long and when grouped together are usually spaced 300 to 400 feet apart. With respect to construction details, they are similar to explosives magazines. Their capacity is not stated in definite figures because the number of components that may be stored in any one magazine depends not only on the capacity but also takes into account the danger of losing all of one type of component if stored in one magazine.

(6) *Ammunition magazines.*—These magazines were designed for the storage of fixed or separate loading shell and shrapnel. They are 51 feet 7 inches wide and 218 feet 8 inches long and when grouped together are usually spaced 800 feet part. They are constructed with concrete foundation walls and piers, hollow tile walls, steel frames, and concrete floors. Construction details are similar to those of explosives magazines. The capacity of these magazines is not stated in definite figures because the number of shell or shrapnel that may be stored therein is regulated by the quantity-distance tables (sec. V) and by other safety requirements which limit the number of shell to a pile and the distances between piles (sec. XIV).

(7) *Warehouses.*—These structures are similar to commercial warehouses. They have solid foundations of concrete, concrete floors, and brick or tile walls, though other materials, such as sheet asbestos, also has been used. Roofs are usually of sheet asbestos or of the built-up type. Warehouses may be used for the storage of small-arms ammunition, sodium nitrate, and other materials which are not explosive hazards.

27. Storage chart for explosives, ammunition, and other hazardous materials.—A chart showing permissible storage for

explosives, ammunition, and other hazardous materials is included in this manual in appendix II.

28. Piling and stacking.—*a.* When a specific method of piling or stacking is not prescribed on ordnance drawings, explosives and ammunition will be piled or stacked in accordance with AR 700-10 and the following special regulations:

(1) Explosives or ammunition in piles will be segregated by lot.

(2) A ventilating space will be maintained between the bottom of the pile and the floor to protect the material in the pile from water and dampness.

(3) Methods used for piling and stacking will provide for good ventilation to all parts of the pile. Dunnage will be used if necessary.

(4) Aisles will be maintained so that units in the pile can be inspected, inventoried, and removed for shipment or surveillance tests.

(5) Partly filled boxes will be marked plainly and placed in conspicuous places on top of the proper piles.

(6) Inflammable material, such as dunnage and boxes, will be eliminated or reduced to an absolute minimum in magazines containing class 9 and class 10 materials.

(7) The requirements of paragraph 89 will be observed carefully.

29. Temperature control.—*a.* Sudden changes in temperature may damage airtight containers, or may result in excessive condensation of moisture in the air. If the temperature in a magazine exceeds 100° F. for a period of more than 24 hours, the magazine will be cooled by wetting the exterior of the building with water or by opening the doors and ventilators after sunset and closing them in the morning. If these methods do not prove effective in lowering the temperature, the commanding officer will decide whether the stores are to be removed to some other magazine, and report such cases to the Chief of Ordnance.

b. When temperature is controlled by opening the doors after sunset, effective measures will be taken to protect the stores against fires, and provision will be made for closing the doors in case of rain.

30. Lightning protection.—*a.* It is the policy of the Ordnance Department to equip all magazines with an efficient lightning protection system. This system is shown and described in detail on drawings and in specifications of the Ordnance Department.

b. The essential parts of the installation are air terminals, conductors, and ground terminals. The air terminals are points of noncorrosive metal elevated as high above the building as possible. Conductors are cables or rods which connect the air terminals with each other and with the ground terminals. Grounds, or earth terminals, are usually copper plates surrounded by charcoal and buried in the ground below the water level of the subsoil. Sometimes charcoal cones only are used and in exceptional cases water mains and railroad tracks have been used as grounds.

c. The purpose of the lightning protection system is to provide a metal path of low resistance for the discharge of electrical currents from the air to the ground without damage to the magazine or its contents. If any of the parts of the system are corroded, broken, or poorly installed, the resistance offered to the passage of electrical currents is increased and they may take the more favorable path through the building and its contents, thus causing fires or explosions. Experience shows that deterioration is most active at the places where the conductors enter the ground.

d. To obtain continuous and reliable protection, lightning protection systems will be inspected semiannually. Once each year each system will be tested electrically in accordance with instructions furnished by the Chief of Ordnance. The results of these tests, together with a description of the defects noted and the repairs made, will be forwarded to the Chief of Ordnance. Instructions for the tests and the equipment to make them, if not already on hand, will be requested from the Chief of Ordnance.

e. Additional requirements for lightning protection systems are covered in applicable ordnance safety bulletins.

31. Care and maintenance of magazines.—*a.* The commanding officer or a duly authorized representative will make regular inspections of each magazine to see if repairs are needed, and to insure that the general safety regulations set forth in this manual, particularly those which refer to the cleanliness of magazines and elimination of fire hazards, are strictly observed.

b. Magazines which are properly maintained will show compliance with the following:

(1) The ground around magazines will be free from dry grass, leaves, and rubbish, and a 50-foot cleared space will be carefully maintained around above-ground magazines.

(2) Fire extinguishers, water barrels, buckets, and other auxiliary fire-fighting equipment, such as gunny sacks, and brooms, at or near magazines, will be arranged in a neat and orderly manner and protected against undue deterioration. They will be placed uniformly in position where they are in plain sight and readily available.

(3) Within the magazine, the floors will be clean and free from dirt, oily spots, or exudate.

(4) Stocks in the magazine will be arranged in an orderly manner with ample aisle spaces for inspection and shipping.

(5) Loose components or rounds of ammunition, packing material, conveyors, skids, and other similar material will not be stored in a magazine.

(6) Magazine placards (O. O. Form 5991) furnished by the Chief of Ordnance will be posted near each door of the magazine so that they are visible when work is being done in the magazine.

(7) Doors and locks will be kept in good working order.

32. Repairs to magazines.—*a.* Repairs will not be made to magazines until it has been decided whether or not the contents are first to be removed. Under normal conditions roofs, lightning rods, ventilators, doors, etc., can be repaired, and minor repairs to the interior of a magazine (except those containing hazardous explosives, such as black powder, TNT, tetryl, or explosive D) can be made without removing the contents of the building.

b. When magazines are repaired, the general safety regulations set forth in this manual will be complied with—particularly those relating to the elimination of fire hazards. In addition, the following special regulations are particularly applicable:

(1) All work will be done by careful, experienced workmen, under competent supervision.

(2) Safety tools will be used when indicated.

(3) The floor in the immediate vicinity of the repair work will be swept carefully.

(4) No work requiring soldering, the melting of asphalt, or the use of blow torches will be done in a magazine containing explosives or ammunition.

(5) No repairs will be made to the interior of a magazine containing bulk explosives, such as black powder, TNT, tetryl, explosive D, until all explosives have been removed.

(6) Magazines in which repair work has been done will be inspected by competent authority after completion of the work.

(7) When melting pots or any other heating apparatus, electrical or otherwise, are authorized by the commanding officer in any magazine area or explosives area in connection with repair work on buildings, all such equipment should be kept at least 100 feet from any magazine or building containing explosives or ammunition and should be baffled or screened when necessary to prevent danger from sparks or flame.

33. Care and maintenance of magazine and explosives areas.—Strict compliance with the general safety regulations and particularly those pertaining to the guarding of stores of explosives and ammunition, the controlling of vegetation in and around the magazine and explosives areas, the maintenance of firebreaks, roads, railroads, and fences, and the posting of warning signs, is essential to the proper care and maintenance of magazine and explosives areas. Old and dilapidated wooden shacks, piles of boxes or dunnage, dry brush, etc., will not be permitted.

34. Safety regulations.—*a.* Safety regulations which are particularly applicable to the storage of explosives and ammunition are as follows:

(1) Containers will be free from loose dirt and grit when stored.

(2) Containers will not be opened or repaired in a magazine. This will be done in a building specifically set aside for this purpose, or in clear weather, in the open at sufficient distance to comply with intraplant quantity-distance tables, but at least 100 feet from any building containing explosives.

(3) Explosives and ammunition in damaged containers will not be stored in a magazine. Such containers will be repaired or the contents thereof transferred to new or serviceable containers.

(4) Open containers and containers with covers not securely fastened will not be allowed in magazines. Containers that have been opened will be closed again as effectively as is required upon manufacture.

(5) Two or more doors, when available, must be unlocked when personnel is working in a magazine in order that more than one means of escape will be available.

SECTION V

QUANTITY-DISTANCE TABLES

35. General.—*a.* This section outlines the quantity-distance requirements which are applicable to the storage and handling of ammunition and explosives. These requirements will be complied with at all ordnance establishments.

b. The tables included in this section are based upon the following basic data:

(1) Records of fires and explosions involving military explosives and ammunition.

(2) Reports covering a comprehensive series of tests at Aberdeen Proving Ground.

(3) The American Table of Distances, published by the Institute of Makers of Explosives, United States of America.

(4) Chapter 87, Laws of 1925, State of New Jersey.

c. Where, in this section, explosives and ammunition are grouped into classes, it is not meant or implied that the articles in a particular class are to be stored together, but merely that the hazards involved are similar for all articles in each group. The materials that may be stored together in one magazine are set forth in appendix II of this manual.

36. Definitions.—*a. Inhabited building.*—(1) Any building customarily used as a habitation, church, schoolhouse, hospital, railroad station, or for other purposes of assembly; including general purpose buildings such as offices, barracks, shops, and power plants. Buildings pertaining to an explosives line or magazine area such as operating buildings, watchmen's shelters, field offices, and packing and shipping buildings are not considered as inhabited buildings. Lands outside of and adjacent to boundaries of military reservations will be considered as possible sites for inhabited buildings.

(2) Watchmen's shelters, field offices, surveillance inspection buildings and bombproofs or shelters for personnel in the magazine area will not be located closer to magazines than the magazine to magazine distance for the quantity and classes of ammunition or explosives involved."

b. Public railway.—Any steam, electric, or other railroad which carries passengers for hire.

c. Public highway.—Any street, alley, road, or navigable stream. A navigable stream is one capable of extensive navigation by barges, tugboats, and other large vessels.

d. Nearest magazine.—The nearest magazine containing explosives or ammunition. The amount of explosives or ammunition permitted in a magazine can sometimes be increased if the nearest magazines are filled with inert materials, thus greatly increasing the distance to the nearest magazine containing explosives or ammunition.

e. Measurements.—Measurements for determining quantities of explosives will be made from the nearest point of the building containing explosives to the nearest point of the magazine, inhabited building, public railway, public highway, or channel of the navigable stream under consideration.

f. Operating building.—Any structure in which operations pertaining to manufacture, processing, packing, or shipping explosives or ammunition are performed.

g. Maximum permitted.—The maximum quantity of explosives or ammunition permitted in any magazine. Maximum quantities are based on limiting losses of military stores as well as on quantity-distance considerations.

37. Explosives hazards and quantity-distance requirements.—The hazards pertaining to a particular class of ammunition or explosives are the characteristics upon which the quantity-distance requirements for that class are based. The relationships between hazards and quantity-distance requirements for certain general classes are as follows:

a. Fire hazards.—Fire is the most common hazard incident to the manufacture, processing, handling, and storage of ammunition, propellant powders, and other explosives. Except under unusual circumstances relating to methods of packing and heights of column for certain types and granulations which are

discussed in paragraph 94, smokeless powder is considered a fire hazard only. Consequently in the smokeless powder tables included in this manual, the quantities and distances shown are for fire protection only. Small-arms ammunition, most pyrotechnics, and chemical ammunition for which no tables are shown also are considered fire hazards only, as regards quantities and distances. Most other items of ammunition and explosives may, as a result of fires, detonate and spread disaster to distances considerably in excess of fire-protection distances.

b. Sympathetic detonations.—A sympathetic detonation is one which immediately follows as a direct result of an initial explosion. It may be the result of propagation, or it may be the result of missiles from the initial explosion. In any case it is an explosion that so closely follows the initial explosion as to be indistinguishable from it.

(1) The magazine to magazine distances and the intraplant distances shown in this section for all classes of ammunition and high explosives are based on New Jersey State law. They are expected to give protection against propagation from explosions in adjoining buildings or magazines.

(2) It will be noted that these distances are in all cases substantially less than those required to protect inhabited buildings against structural damage and it is not expected that intraplant or magazine to magazine distances will give protection against structural damage.

c. Missile hazards.—Explosions involving high explosive shell or loaded ammunition components introduce a hazard not normally present in commercial explosives or small-arms ammunition manufacturing plants. These hazards are missiles which may be projected either as pieces of broken up shell cases or other components, or complete projectiles which may and often do explode upon impact or as a result of heating in burning explosives or other fires. Some of the worst disasters have resulted from high explosive shell spreading explosions from building to building in a plant. Missile distances prescribed in the quantity-distance tables for classes 3, 4, 5, 6, and 7 are based upon tests made at Aberdeen Proving Ground. These distances do not take into account occasional missiles which may be thrown a mile or more. They are based upon the distance within which most missiles will fall.

d. Concussion.—The effects of the concussion produced by th detonation of explosives constitutes the commonest hazard a ciated with explosives. The distances given in the tables for classes 8, 9, and 10 are expected to give protection against the concussion effect of explosions. They are identical with the American Table of Distances published by the Institute of Makers of Explosives. Concussion hazards have been divided into three separate classes as follows:

(1) *Structural damage to inhabited buildings.*—The distances shown in tables 8, 9, and 10 for inhabited buildings represent the distances at which buildings will be safe from substantial structural damage. Minor damage such as the breaking of window glass and the shaking down of plaster and possible damage from flying missiles is not considered as substantial structural damage. The term "substantial damage" may be defined as follows:

(*a*) *In stone or brick houses.*—The serious weakening of or displacement of portions of supporting walls (i. e., foundations, side walls, or interior supports) and the breaking of rafters or other important roof supports or floor joists.

(*b*) *In frame buildings.*—The serious weakening of or displacement of foundations, the breaking of any of the main supports in the side walls or interior supporting walls, and the breaking of any main supports of the roof or floors.

(2) *Structual damage to railroad equipment.*—The distances at which railroad cars are considered safe from the concussion effects of explosions has been fixed in the American Table of Distances at 60 percent of the inhabited building distance. These distances have been used in tables 8, 9, and 10. The use of the lesser distances was based on the following considerations:

(*a*) The lesser height and smaller area of railroad trains exposed to concussion, and the greater strength of railroad cars to resist concussion, as compared with buildings.

(*b*) The fact that while a building is stationary and subject to any risk constantly, the presence of a train is only temporary.

(3) *Injury to persons on public highways.*—The public highway distances shown in tables 8, 9, and 10 were taken from the American Table of Distances. They represent the distances at which persons in the open are safe from the concussion effects of explosions. The cases tabulated by the Institute of Makers of Explosives did not conform to a fixed pattern, and in arriving at distances which would be safe and well beyond the distances at which injuries had actually occurred, public highway dis-

tances were fixed in the American Table of Distances at one-half the railroad distance or at 30 percent of the inhabited building distances.

38. Classes and quantity-distance tables for military explosives and ammunition.—*a.* The explosive contents of ammunition or components are shown on ordnance drawings; but if these are not available, the information desired should be requested from the Chief of Ordnance. The quantities shown in the tables herein were computed in the following manner:

(1) For smokeless powder the quantity in pounds is the net weight of the powder in the boxes (bulk powder) or propelling charges.

(2) For pyrotechnics the quantity is the gross weight of the boxes and contents.

(3) For fixed ammunition the pounds of explosives are computed as follows: If a magazine contains 200,000 rounds of 75 mm. H. E. shell M48, the amount of explosives in the magazine is 200,000×1.47=294,000 pounds. (1.47 pounds is the approximate weight of the high explosive in the shell.) The smokeless powder in the cartridge case is not classed as an explosive in this case and is not included in the computation.

(4) For separate loading shell and bombs the pounds of explosives are computed as follows: If a magazine contains 30,000 155-mm. howitzer shell, M102, the amount of explosives in the magazine is as follows: 30,000×15.56=466,800 pounds. (15.56 is the approximate weight of the high explosives in the shell.)

b. When military explosives and ammunition are not packed in accordance with the provisions of approved drawings and specifications, they will be stored in accordance with special instructions issued by the Chief of Ordnance.

c. When military explosives and ammunition are packed in accordance with the requirements of approved drawings and specifications, and are stored in accordance with storage drawings, or as prescribed in this manual, they are classified as indicated below, and will be stored in accordance with the quantity-distance tables shown.

(1) *Class 1—Small-arms ammunition and mechanical time fuzes without boosters.*—These materials are principally fire hazards. No limit is placed on the storage of small-arms ammunition, but the limits imposed by paragraph 38*c* (3) on class 3 material apply also to mechanical time fuzes.

(2) *Class 2—Smokeless powder, pyrotechnics, and chemical ammunition filled with phosphorus.*—These materials may become unsafe under extreme conditions of moisture and high temperature. They burn with intense heat.

Class 2—Quantity-distance table

SMOKELESS POWDER IN CONTAINERS,[1] PYROTECHNICS, OR CHEMICAL AMMUNITION CONTAINING PHOSPHORUS

Quantity		Unbarricaded distance[2] in feet from nearest—			
Pounds (over)—	Pounds (not over)—	Inhabited building	Public railway	Public highway	Magazine[3]
100	1,000	75	75	75	60
1,000	5,000	115	115	115	75
5,000	10,000	150	150	150	100
10,000	20,000	190	190	190	125
20,000	30,000	215	215	215	145
30,000	40,000	235	235	235	155
40,000	50,000	250	250	250	165
50,000	60,000	260	260	260	175
60,000	70,000	270	270	270	185
70,000	80,000	290	290	290	190
80,000	90,000	295	295	295	195
90,000	100,000	300	300	300	200
100,000	200,000	375	375	375	250
200,000	300,000	450	450	450	300
300,000	400,000	525	525	525	350
400,000	500,000	600	600	600	400

SMOKELESS POWDER IN BULK[4]

100	1,000	100	100	100	60
1,000	5,000	150	150	150	75
5,000	10,000	200	200	200	100
10,000	20,000	250	250	250	125
20,000	30,000	285	285	285	145
30,000	40,000	310	310	310	155
40,000	50,000	330	330	330	165
50,000	60,000	315	315	315	175
60,000	70,000	360	360	360	185
70,000	80,000	375	375	375	190
80,000	90,000	390	390	390	195
90,000	100,000	400	400	400	200
100,000	200,000	500	500	500	250
200,000	[5] 300,000	600	600	600	300

[1] Smokeless powder in containers is intended to mean any smokeless powder stored in boxes, powder cans, cartridge storage cases, or any container used for the storage of smokeless powder.

[2] Unbarricaded distances as shown always will be used when considering aboveground magazines in which smokeless powder is stored. One-half the above distances are authorized for separation of igloo type magazines containing smokeless powder.

[3] Distances shown are applicable to operations succeeding the graining operation in smokeless powder plants.

[4] Smokeless powder in bulk is intended to mean any smokeless powder not stored in containers, such as is found in dry houses, blenders, bag loading, and hand blending operations.

[5] Maximum quantity permitted in any 1 magazine.

(3) *Class 3—Point-detonating fuzes, minor caliber base-detonating fuzes, powder train and antitank-mine fuzes, packed separately in boxes; bomb fuzes, packed with fin assemblies in accordance with the provisions of paragraph 127a (3).*—The amount of explosives in articles of this class, including the booster, varies from 30 to 500 grains, except in the case of bomb fuzes packed with fin assemblies, which contain a charge of approximately 1,000 grains. These fuzes usually explode progressively, not more than a box or two at a time. Pressures which would cause serious structural damage to adjacent magazines are not usually generated, and missiles are small and of light weight, usually falling with 300 feet. The quantity of fuzes stored in a single magazine will be kept to the minimum consistent with available storage capacity. The storage of more than 50,000 fuzes of any one model, or a total of more than 150,000 fuzes of all models in a single magazine will not be permitted except by specific authority of the Chief of Ordnance.

Class 3—Quantity-distance table

Quantity, pounds of explosives (not over)—	Unbarricaded distance[1] in feet from nearest—			
	Inhabited building[2]	Public railway[2]	Public highway[2]	Magazine
10,000[3]	400	400	400	300

[1] These distances will not be reduced by barricades. One-half the above distances are authorized for concrete igloo magazines, except at the door end.

[2] Missile distance.

[3] Maximum permitted in any one magazine.

(4) *Class 4—When packed in accordance with ordnance drawings and specifications: Fixed and semifixed high-explosive shell (complete rounds), light mortar ammunition, fragmentation bombs in wooden crates, grenades, and shrapnel of all calibers, fuzed or unfuzed, and blank ammunition for cannon.*—Articles in this class usually explode progressively, only a few boxes at a time, many explosions of individual rounds being of a very low order. Pressures which would cause serious structural damage to adjacent magazines are not usually generated, and most missiles would fall within 600 feet.

Class 4—Quantity-distance table

Quantity, pounds of explosives (not over)—	Distance [1] in feet from nearest—			
	Inhabited building [2]	Public railway [2]	Public highway [2]	Magazine
500,000 [3]	1,200	1,200	1,200	300

[1] These distances will not be reduced by barricades. One-half the above distances are authorized for concrete igloo magazines, except at the door end.
[2] Missile distance.
[3] Maximum permitted in any one magazine.

(5) *Class 5—Separate-loading shell of all calibers, loaded with explosive D, fuzed or unfuzed; and shell loaded with explosive D, fuzed or unfuzed, not assembled to or packed with cartridge cases.*—These shells usually explode one at a time, and in practically all cases with low order. As only one shell should be involved in an explosion, the missiles are limited both as to number and range and most missiles will fall within 1,200 feet.

Class 5—Quantity-distance table

Quantity, pounds of explosives (not over)—	Distance [1] in feet from nearest—			
	Inhabited building [2]	Public railway [2]	Public highway [2]	Magazine
600,000 [3]	1,200	1,200	1,200	300

[1] These distances will not be reduced by barricades. One-half the above distances are authorized for concrete igloo magazines, except at the door end.
[2] Missile distance.
[3] Maximum permitted in any one magazine.

(6) *Class 6—Major and medium caliber base-detonating fuzes, bomb fuzes; and adapters and boosters for high explosive shell, bursters for chemical shell, and for bombs, packed separately in boxes.*—The amount of explosives in single items of this class usually does not exceed one-half pound. They usually explode progressively, by piles. The number involved in any explosion is limited by making the piles small and separating them by prescribed distances determined by actual detonation tests. Structural damage caused by the pressures generated usually is limited to adjacent magazines and the missiles are light and usually fall within 600 feet. The quantity of fuzes stored in a single magazine will be kept to the minimum consistent with available storage capacity. The storage of more than 50,000

fuzes of any one model, or a total of more than 150,000 fuzes of all models in a single magazine will not be permitted except by specific authority of the Chief of Ordnance.

Class 6—Quantity-distance table

Quantity, pounds of explosives (not over)—	Unbarricaded distance [1] in feet from nearest—			
	Inhabited building [2]	Public railway [2]	Public highway [2]	Magazine
100,000 [3]	1,800	900	450	300

[1] These distances will not be reduced by barricades. For concrete igloo magazines (except at the door end) one-half of the above distances are authorized. When items of this Class are stored in igloo magazines (except when segregated into piles in accordance with drawing No. D-8381) the quantity and distance requirements prescribed for classes 9 and 10 will apply, except that no distances smaller than one-half the distances quoted in the above Class 6 Quantity-Distance Table are authorized.
[2] Missile distance.
[3] Maximum permitted in any one magazine.

(7) *Class 7—Separate-loading loaded shell of all calibers, fuzed or unfuzed, except those loaded with explosive D; and loaded shell, except those loaded with explosive D, fuzed or unfuzed, not assembled to or packed with cartridge cases.*—Shell in this class usually explode progressively by piles. The number involved in any one explosion is limited by making the piles small and separating them by prescribed distances which have been determined by actual detonation tests. Structural damage caused by the pressures generated is usually limited to adjacent buildings. Most missiles will fall within 1,500 feet.

Class 7—Quantity-distance table

Quantity, pounds of explosives (not over)—	Unbarricaded distance [1] in feet from nearest—			
	Inhabited building [2]	Public railway [2]	Public highway [2]	Magazine
500,000 [3]	1,800	1,800	1,800	300

[1] These distances will not be reduced by barricades. For concrete igloo magazines (except at the door end) one-half the above distances are authorized. When items of this class are stored in concrete igloo magazines (except when segregated into piles in accordance with drawing No. 19-48-12) the quantity and distance requirements prescribed for Classes 9 and 10 will apply except that no distances less than one-half the distances quoted in the above class 7 Quantity-Distance Table are authorized.
[2] Missile distance.
[3] Maximum permitted in any one magazine.

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(8) *Class 8—Primers, detonators, primer-detonators for bombs, grenade fuzes, and blasting caps, packed in accordance with Ordnance drawings and specifications.*—All in a magazine may explode at one time, but as the total amount of explosives involved is limited, structural damage usually is limited to adjacent magazines. This class of ammunition forms light missiles which have a very limited range.

Class 8—Quantity-distance table

Quantity, pounds of explosives (not over)—	Unbarricaded distance in feet from nearest—			
	Inhabited building [1]	Public railway [1]	Public highway [1]	Magazine
2,000	960	580	300	300
5,000	1,200	720	360	300
10,000	1,500	900	450	300
15,000	1,610	970	490	300
20,000 [2]	1,740	1,040	520	300

[1] American Table of Distances, requirements for explosives in the form of blasting caps.
[2] Maximum permitted in any one magazine.

(9) *Class 9—Flashlight powder, demolition blocks, spotting charges, black powder, bulk priming explosives; bulk initiating explosives such as tetryl, and bulk high explosives such as TNT and explosive D.*—Priming explosives such as mercury fulminate and lead azide will be stored in accordance with special instructions to be issued by the Chief of Ordnance. In a fire, black powder usually explodes and TNT and explosive D usually burn, but may explode. Since these explosives are similar to the commercial explosives on which the American Table of Distances was based, they are stored in accordance with this table.

(10) *Class 10—Demolition bombs, fragmentation bombs in metal crates, or bundles, photoflash bombs, and H. E. antitank mines.*—All in a magazine may explode. In this case, structural damage will be limited to the distances specified for inhabited buildings in the American Table of Distances for similar quantities of commercial bulk explosives, and most missiles will also fall within these distances. Quantities of class 10 explosives will be stored in accordance with the table for classes 9 and 10, except that the distances applicable to fragmentation bombs will not be less than those stated in the Class 4 Quantity-Distance

Table, but may be one-half the distances as stated in the Class 4 Quantity-Distance Table when storage is in concrete igloo magazines; however, the door end is not considered barricaded.

Classes 9 and 10—Quantity-distance table

Quantity of explosives		Unbarricaded distance in feet from nearest—			
Pounds over—	Pounds not over—	Inhabited building [1]	Public railway [1]	Public highway [1]	Magazine [2]
......	50	145	90	45	60
50	100	240	140	70	80
100	200	360	220	110	100
200	300	530	320	160	120
300	400	640	380	190	130
400	500	720	430	220	140
500	600	800	480	240	150
600	700	860	520	260	155
700	800	920	550	280	165
800	900	980	590	300	170
900	1,000	1,020	610	310	180
1,000	1,500	1,060	640	320	210
1,500	2,000	1,200	720	360	230
2,000	3,000	1,300	780	390	260
3,000	4,000	1,420	850	420	280
4,000	5,000	1,500	900	450	300
5,000	6,000	1,560	940	470	300
6,000	7,000	1,610	970	490	300
7,000	8,000	1,660	1,000	500	300
8,000	9,000	1,700	1,020	510	300
9,000	10,000	1,740	1,040	520	300
10,000	15,000	1,780	1,070	530	300
15,000	20,000	1,950	1,170	580	300
20,000	25,000	2,110	1,270	630	300
25,000	30,000	2,260	1,360	680	300
30,000	35,000	2,410	1,450	720	300
35,000	40,000	2,550	1,530	760	300
40,000	45,000	2,680	1,610	800	300
45,000	50,000	2,800	1,680	840	300
50,000	55,000	2,920	1,750	880	400
55,000	60,000	3,030	1,820	910	400
60,000	65,000	3,130	1,880	940	400
65,000	70,000	3,220	1,940	970	400
70,000	75,000	3,310	1,990	1,000	400
75,000	80,000	3,390	2,040	1,020	400
80,000	85,000	3,460	2,080	1,040	400
85,000	90,000	3,520	2,120	1,060	400
90,000	95,000	3,580	2,150	1,080	400
95,000	100,000	3,630	2,180	1,090	400
100,000	125,000	3,670	2,200	1,100	800
125,000	150,000	3,800	2,280	1,140	800
150,000	175,000	3,930	2,360	1,180	800
175,000	200,000	4,060	2,440	1,220	800
200,000	225,000	4,190	2,520	1,260	800
225,000	[3] 250,000	4,310	2,590	1,300	800

[1] American Table of Distances, requirements for bulk explosives.
[2] Magazine distances conforming with the requirements of paragraph 41 may be authorized under special conditions.
[3] Maximum permitted in any one magazine.

(11) *Class 11—Chemical ammunition (except ammunition containing phosphorus).*—This ammunition is not considered an explosive hazard, and no limit has been placed on the storage of this material, except that storage must comply with the requirements of part IV of this manual, and with the storage chart, appendix II.

(12) *Class 12—Explosives such as ammonium nitrate, DNT, and wet nitrocellulose.*—These materials are insensitive and can be detonated only by very strong initiation. When stored in an explosives area where there is a possibility that explosives may be projected into them, they will be stored in accordance with the regulations for class 9 explosives. When stored in an area with fire hazards only, and separated by inhabited building distances from areas containing explosives or ammunition, these materials may be stored in accordance with the regulations for smokeless powder.

39. Separation within magazines or other buildings.—*a.* The quantity-distance tables for ammunition and ammunition components of classes 3, 4, 5, 6, and 7 are based on the assumption that, on initiation, mass detonations will not occur and that missile distances are the controlling considerations.

b. On initiation, ammunition of classes 3, 4, and 5 may be expected to explode progressively, a few boxes at a time, whether or not the piles are separated within the magazine.

c. (1) Ammunition of class 6 stored in above-ground magazines, will be spaced in piles containing not over 5,000 pounds of explosives each, with the piles spaced a minimum of 2 feet apart. Otherwise, it must be assumed that, on initiation, the ammunition in the magazine will detonate en masse, and quantity-distance requirements including the maximum permitted in each magazine, will be those prescribed for classes 9 and 10. However, the limit per magazine will be 100,000 pounds, but not more than 50,000 fuzes of one model, nor a total of over 150,000 fuzes of all models will be stored in a single magazine.

(2) Ammunition of class 7, stored in above-ground magazines, will be placed in piles containing not over 15,000 pounds of explosive each, and spaced in accordance with the Ordnance drawing 19-48-12. Otherwise, it will be assumed that, on initiation, all ammunition in the magazine will detonate en masse, and quantity-distance requirements including the maximum permitted in each magazine, will be those prescribed for classes 9 and 10.

d. When ammunition of classes 6 and 7 is stored in igloo magazines in accordance with ordnance drawings, aisle spacing is not sufficient to preclude mass detonation; therefore, quantity-distance requirements, including the maximum permitted in each magazine, will be those prescribed for classes 9 and 10.

40. Intraplant distances.—*a.* All high explosives and black powder operating buildings will be located one from each other and from other buildings on explosives plants in which persons are regularly employed, and all service magazines will be located from buildings on explosives plants in which persons are regularly employed in conformity with the following table:

Intraplant quantity-distance table[1]

Quantity of explosives[2]		Unbarricaded distance in feet, separate building, or within substantial dividing walls
Pounds over—	Pounds not over—	
----------	10	----------
10	25	40
25	50	60
50	100	80
100	200	100
200	300	120
300	400	130
400	500	140
500	750	160
750	1,000	180
1,000	1,500	210
1,500	2,000	230
2,000	3,000	260
3,000	4,000	280
4,000	5,000	300
5,000	6,000	320
6,000	7,000	340
7,000	8,000	360
8,000	9,000	380
9,000	10,000	400
10,000	12,500	420
12,500	15,000	450
15,000	17,500	470
17,500	20,000	490
20,000	25,000	530
25,000	30,000	560
30,000	35,000	590
35,000	40,000	620
40,000	45,000	640
45,000	50,000	660
50,000	55,000	680
55,000	60,000	700
60,000	65,000	720
65,000	70,000	740
70,000	75,000	770
75,000	80,000	780
80,000	85,000	790
85,000	90,000	800
90,000	95,000	820
95,000	100,000	850
100,000	125,000	900
125,000	150,000	950
150,000	175,000	1,000
175,000	200,000	1,050
200,000	225,000	1,100
225,000	250,000	1,150

[1] New Jersey State law for intraplant quantities and distances.
[2] Applies to high explosives or items loaded with high explosives.

b. If the hazards involved require dividing an operating line into separate buildings, such hazards are great enough to require the use of full intraplant distances between buildings unless effective separate barricades are provided as described in paragraph 43, in which case these distances may be halved.

c. In cases in which it is impracticable, or undesirable from a production point of view, to separate operating buildings by prescribed safety distances, their separation by lesser distances may be approved by the commanding officer in special cases. Buildings so located will be considered as separate rooms within a single building, and the total amount of explosives contained in all buildings so located will not exceed the maximum authorized for a single building.

d. In operating lines of explosives manufacturing or ammunition loading plants, subbuildings in which persons are not regularly employed or which are visited only intermittently by operators may be placed adjacent to operating buildings without affecting the safety distances determined by main operating buildings, provided the maximum amounts of explosives contained in each subbuilding is limited by its distance from the nearest main operating building in accordance with the intraplant quantity-distance table.

41. Basic magazine quantity-distance rule.—*a*. The laws of New Jersey (latest revision, ch. 27, Laws of 1941, March 28, 1941) require a distance of 200 feet separation for magazines containing 5,000 to 25,000 pounds of explosives, plus 2⅔ feet additional distance for each 1,000 pounds of explosives in excess of 25,000 pounds. This rule is the basis for the table shown in *paragraph 38c (10)*, but *for reasons of policy the latter table* shows only three magazine distances for quantities varying from 5,000 to 250,000 pounds. This basic rule is restricted to intraplant use in locating service magazines from each other and to such other uses as may be authorized by the Chief of Ordnance in specific cases.

42. Special area distances.—*a*. In the layout of explosives manufacturing and ammunition loading plants, each operating line, *storage area, and administrative area* will *constitute* a separate group of buildings and facilities, so located that any group is separated from all the others by inhabited building distances as shown in paragraph 38 of this manual. The distance to be used in each case will be the greater of the following:

(1) Inhabited building distances based on the missile hazards for the particular type of ammunition being loaded (tables for classes 3 to 8, inclusive).

(2) Inhabited building distances based on structural damage for the total amount of high explosives involved (table for classes 9 and 10).

b. Public railways which do not carry passengers will be permitted to pass not closer than 400 feet from magazines. However, they must be separated by railway distances from operating buildings.

c. In future construction, railroad classification yards designed to receive explosives or ammunition will be separated from inhabited buildings, administration areas, magazines containing explosives or ammunition and operating buildings containing explosives or ammunition by a minimum distance of 1,800 feet. However, this distance may be decreased to a minimum of 1,400 feet in the case of concrete igloo magazines.

d. New depot storage areas will be divided into blocks of not to exceed 100 igloo magazines each, the blocks to be separated by minimum distances of 1,400 feet. Each block will contain not more than 25,000,000 pounds of explosives. Storage areas will be separated from administration and other inhabited building areas by inhabited building distances based on the quantities and types of ammunition and explosives contained in the magazines.

e. Renovation plants and reconditioning plants must be located at inhabited building distances from magazine areas. However, the inhabited building distance governing the location of such plants may in some cases be based upon the amount of explosives in the renovation or reconditioning plant rather than upon the amount of explosives in magazines in the magazine area.

43. Barricades.—*a*. *Definition*.—Whenever an explosives manufacturing building or magazine is effectually screened from another explosive manufacturing building or magazine, railroad, or highway, either by natural features of the ground or by efficient artificial barricades of such height that any straight line drawn from the top of any side wall of the factory building or magazine to any part of the explosives plant building or building to be protected will pass through such intervening natural or artificial barricade, and any straight line drawn from the top of any side wall of the factory building or magazine to any point 12 feet above the center of the railroad or highway to be protected will pass through such intervening natural or artificial barricade, the applicable distance (except missile and smokeless powder distances) as prescribed by the quantity and distance table, and the intraplant quantity and distance table, and the distances separating magazines may be reduced one-half. (See par. 43*d*.)

b. *Igloo magazines*.—(1) When protected by barricades at the door end, approved, reinforced-concrete, arch-type, earth-covered (igloo) magazines are considered barricaded in all directions; and "barricaded distances" may be used as minimum safe distances in locating them with reference to inhabited buildings, public railways, public highways, operating buildings, or other magazines. No other type of magazine is considered barricaded unless separate barricades are provided. Where concrete igloo magazines are not barricaded at the door end "unbarricaded distances" will be used in locating them from structures and facilities which lie in front of the magazines and within the area bounded by lines drawn from the door and inclined by 30° from a line drawn perpendicular to the front of the magazine.

c. It is not the policy of the Ordnance Department to erect barricades around magazines; but if necessary to meet dangerous local conditions, such barricades will be constructed in accordance with drawings and specifications approved by the Chief of Ordnance.

d. A barricade used for the purpose of reducing safety distances must be constructed separate from the building it is to screen and must be located at a minimum distance of 4 feet from such a building. It may be either natural or artificial. If artificial, it should consist of earth or sand fill with a minimum width of 8 feet at the top. Either one or both sides may be revetted, or supported by concrete, timber, or masonry walls. Barricades are authorized for use in reducing both intraplant distances and structural damage distances, but not for reducing missile distances. Approved reinforced-concrete, arch-type, earth-covered (igloo) magazines are considered barricaded with respect to missiles. Other types of igloo magazines are not considered barricaded in any respect unless separate barricades are provided.

e. Flash barricades which are authorized for the purpose of preventing the spread of fires will not be used for the purpose of reducing safety distances.

44. Dividing walls.—*a*. A definition of the words "within substantial dividing walls" with reference to intraplant distances between factory buildings is illustrated by the following example. If a building contains 4,000 pounds of explosives and is provided with a "substantial dividing wall," dividing the building into two rooms, one containing 3,000 pounds of explosives and the other 1,000 pounds, the distance between the room containing 3,000 pounds of explosives and the nearest operating factory building is based on the distance required for 3,000 pounds of explosives. To describe it otherwise, "a substantial dividing wall" would, in the event of a detonation of the larger quantity of explosives, prevent the sympathetic detonation of the lesser quantity of explosives in the adjoining room. The distance to the next building is governed by the 3,000 pounds instead of the total of 4,000 pounds.

b. Substantial dividing walls used to separate buildings into individual rooms will not be added to existing buildings except by authority of the Chief of Ordnance. It is not expected that substantial dividing walls will materially limit structural damage. If all of the explosives on both sides of a substantial dividing wall are prevented from exploding en masse the purpose for which the wall was provided has been accomplished, even though the wall may be demolished and structural damage in the plant may be severe. A substantial dividing wall must extend to the roof and to the side walls of the building or room which it divides into separate rooms. It must consist of concrete at least 12 inches thick, reinforced on both sides by rods at least ½ inch in diameter, located on maximum centers of 12 inches both vertically and horizontally. This paragraph should not be interpreted as discouraging the use of barricades of the bench or wing-wall type to cut down operating hazards; but for the purpose of establishing safety distances, such barricades should not be considered as dividing the explosives contained within the building or room into separate lots.

45. **Loaded railroad cars.**—*a*. Cars of loaded ammunition, such as shell, complete rounds, smokeless powder in containers, or propelling charges in containers, if alongside an operating building, are considered as separate rooms of that building. The space in the car opposite the open doors will not be used for storage, except under the following conditions:

(1) Where it is possible to spot the car so that its doors are opposite a blank wall with a minimum of 5 feet on either side of the car door to the doors or windows of the building, such cars may be fully loaded.

(2) Where doors and windows in a building prevent the solution suggested in paragraph (1) above, the car door adjacent to the building may be closed. Thus a dividing wall is interposed and the car may be fully loaded through the opposite car door.

b. If more than one car is located at an operating building, a separation of at least 10 feet between cars will be required.

c. Cars of bulk high explosives, loaded H. E. bombs, or bulk smokeless powder will be figured at full hazard. If alongside an operating building, they will be considered at "within the building" and not as within "separate dividing walls" unless such walls are specially provided or existing walls are utilized.

d. Cars or trucks containing ammunition or explosives will not be spotted between magazines or other buildings where they reduce effective safety distances and may act to transmit fires or explosions from building to building.

e. Railroad cars used for picking up or distributing shipments in a magazine area must be loaded in accordance with the storage table contained in Appendix II. Except when the quantity involved is very small, trucks so used will be loaded in accordance with the storage tables referred to. The use of the Interstate Commerce Commission loading table is restricted to cars spotted at shipping or receiving buildings or moving between the shipping and receiving buildings referred to in paragraph 25 and common-carrier interchanges.

Section VI

PACKING, MARKING, AND SHIPPING

46. **General.**—The general regulations governing the packing, marking, and shipping of military supplies are set forth in Army Regulations 30-955. This section contains special regulations applying to explosives and ammunition.

47. Packing.—*a.* The packing of explosives and other dangerous articles for shipment will be in accordance with Ordnance drawings and specifications. Where applicable, Interstate Commerce Commission regulations will be observed. For the packing of items not covered by drawings and specifications or Interstate Commerce Commission regulations, special instructions will be issued by the Chief of Ordnance.

b. When containers which comply with United States Army specifications are not available for shipments of explosives or other dangerous articles, containers which comply with the Interstate Commerce Commission regulations will be used. This applies particularly to the shipment of deteriorated explosives or ammunition, and to powder, explosives, and loaded components of ammunition obtained from salvage operations.

48. Marking.—*a.* The term "marking" as used in this manual includes the painting, stenciling, and stamping of containers and of the ammunition itself.

b. Explosives and other dangerous articles offered for shipment on a common carrier will be marked to comply with Interstate Commerce Commission regulations.

c. Explosives and ammunition are marked in accordance with United States Army specifications and drawings, and are further described and explained in appropriate field manuals and standard nomenclature lists. Although the markings are primarily for the identification of the material from a military standpoint, they also will be made to comply with Interstate Commerce Commission regulations.

d. When an Ordnance establishment repaints or re-marks explosives or ammunition containers, ammunition, or ammunition components, the new painting or marking will be a facsimile of the painting and marking of the original container or ammunition, unless the Chief of Ordnance issues specific instructions to the contrary. Explosives and ammunition obtained from salvage operations, and material which has lost its identity will be clearly marked to show the nature of the material. If offered for shipment the material will be marked to comply with the requirements of Interstate Commerce Commission regulations.

49. Lot numbers.—*a.* Lot numbers are used in the identification of military explosives and ammunition. Except for certain unserviceable material, the lot number always appears upon the packing boxes or containers. It also appears on the data cards and in most cases upon the ammunition itself.

b. Lot numbers usually consist of letters and figures which represent the initials of the manufacturer or loading company, the number of the War Department procurement order, the serial number of the lot and, in some cases, the date.

c. The identification of military explosives and ammunition by lot number is essential for the surveillance activities of the Ordnance Department. It is the means whereby stocks are conserved or utilized to the best advantage, and defective or deteriorated ammunition is withdrawn from service. It is used also in selecting ammunition for issue, because the ballistics or performance of ammunition when fired may vary from lot to lot.

50. Interstate Commerce Commission.—*a.* Except for water shipments, the Interstate Commerce Commission is impowered to regulate the transportation of explosives and other dangerous articles in interstate commerce within the limits of jurisdiction of the United States. However, Interstate Commerce Commission regulations provide that shipments of explosives or other dangerous articles offered by or consigned to the War or Navy Departments of the United States Government may be packed, including limitations of weight, in accordance with either I. C. C. regulations, or War or Navy Department regulations.

51. The Bureau of Explosives.—*a.* The Interstate Commerce Commission regulations covering shipments of explosives and other dangerous articles by rail include the following:

"The services of the Bureau for the safe transportation of explosives and other dangerous articles, hereinafter called Bureau of Explosives, will be utilized by the commission in the execution of these regulations. This Bureau will make inspections and conduct investigations, and will confer with manufacturers and shippers with a view to determining what regulations will within reasonable limits afford the highest degree of safety in packing and preparing these dangerous articles for shipments and in transporting the same. The Commission will avail itself of the expert knowledge thus developed, and in formulating amendments to these regulations, while not bound thereby, will give due weight to the expert opinions thus obtained."

b. The Bureau of Explosives was organized in 1906 by the American Railway Association. Nearly all common carriers are members of the American Railway Association and comply with the rules and regulations issued by the Bureau of Explosives. Inspectors of the Bureau of Explosives are stationed throughout the country to observe, investigate, and report upon shipping methods. Common carriers utilize the services of these inspectors to enforce regulations and approved practices, and to assist shippers.

52. State and municipal laws and ordinances.—*a*. In addition to Federal laws governing interstate transportation of explosives and other dangerous articles, each State and nearly all municipalities have laws or ordinances regulating the transportation of explosives and other dangerous articles within their jurisdiction. Harbor regulations of the ports of New York, or Baltimore, and city ordinances requiring motor-trucks or wagons carrying explosives to display a red flag or placards, are examples of such State and municipal laws and ordinances.

b. Shipments of explosives and ammunition made by Ordnance establishments will comply with applicable requirements of Interstate Commerce Commission regulations, port and harbor regulations, State and municipal laws, and Bureau of Explosives recommendations.

53. Rail shipments.—The Interstate Commerce Commission regulations which govern the transportation of explosives and other dangerous articles by rail are essentially safety regulations and describe in detail how such shipments will be handled, loaded, braced, stayed, and placarded. (See also AR 30-995, Transportation of Supplies.) Bureau of Explosives Pamphlet No. 6 contains descriptions, photographs, and drawings of recommended methods of bracing and staying shipments. These recommendations, although for commercial explosives and other dangerous articles, can be adapted readily to military explosives and ammunition, and will be followed in all cases in which bracing and staying methods are not prescribed by Ordnance drawings and specifications.

54. Water shipments.—*a*. Transportation of explosives and other dangerous articles by water in vessels engaged in commercial service is regulated by the Bureau of Marine Inspection and Navigation, United States Department of Commerce. Shipments will comply with applicable portions of the regulations

of this Bureau. Shipments overseas will be made in accordance with the regulations of the carrier, usually the Quartermaster Corps or the Navy Department. (See AR 30-1270, Transportation by Water of Explosives, Inflammables, and Chemical Warfare Materials.)

55. Motortruck shipments.—*a*. Transportation of explosives and other dangerous articles by truck is covered by Interstate Commerce Commission Motor Carrier Regulations, Part 7. Such of these regulations as are applicable will be complied with.

b. Contracts for the transportation of ammunition and explosives by common or contract carriers will be let only to those contractors who use vehicles licensed by the Interstate Commerce Commission specifically for the transportation of explosives and other dangerous articles.

56. Special shipping requirements.—*a*. When explosives and ammunition are shipped, the material will be indentified carefully on bills of lading or shipping tickets by shipping name, caliber, type, mark or model number, manufacturer's name or initials, lot number, and such other information as may be required by additional instructions issued by the Chief of Ordnance.

57. Safety regulations for shipments.—*a*. The commanding officer will obtain and keep available for reference the following:

(1) Copies of Interstate Commerce Commission regulations, including Part 7, Motor Carrier Safety Regulations;

(2) Bureau of Explosives Pamphlet No. 6;

(3) Regulations Governing the Transportation, Storage, Stowage, or Use of Explosives or Other Dangerous Articles, or Substances and Combustible Liquids on Board Vessels, published by the Bureau of Marine Inspection and Navigation, United States Department of Commerce;

(4) Copies of State and municipal laws, and port or harbor regulations which are applicable to shipments from his establishment.

b. Any shipment received in badly damaged condition will be reported in detail to the Chief of Ordnance.

c. Containers of explosives or ammunition will not be opened or repaired in any car, boat, truck, or magazine containing explosives or ammunition. Ordinarily this work will be done in buildings specifically designated for such work. In clear weather it may be done in the open, at a distance of not less than 100 feet from the magazine, car, boat, or truck; but in no case at a distance less than that prescribed in the intra-plant quantity-distance table for the quantity of explosives involved in the operation.

d. Cars, boats, or motortrucks in which explosives or ammunition are recieved will be inspected by a competent person after unloading, to see that they are clean and free from loose explosives or other inflammable materials, and that explosives placards are removed. Explosives sweepings will be destroyed.

e. During the loading and unloading of cars and trucks if the cars or trucks are on a grade the brakes will be set and the wheels will be checked.

f. Explosives and ammunition will be handled carefully. Bale hooks will not be used, and containers will not be tumbled, dragged, thrown, or dropped on each other or on the floor.

g. If artificial light is required to examine shipments of explosives and ammunition, only such lights as comply with the requirements of paragraph 169c will be used.

h. If the loading or unloading of cars is not completed during working hours, car doors will be closed and locked or sealed.

i. Doors to cars or magazines will be closed when locomotives which do not comply with the provisions of paragraph 7a (21) are passing.

j. If the loading or unloading is done outside the magazine area, fire hazards such as leaves, dry grass, and other combustible materials will be removed from the immediate vicinity, and fire-fighting equipment must be readily available.

k. A permanent record of car numbers and seals will be kept.

l. Motortrucks used for the transportation of explosives and ammunition will be inspected regularly by a competent person to see that electric wiring, lights, brakes, gasoline tanks and lines are in good working order and that oil pans under engines are clean. The fire-fighting equipment, carried on the truck, will be inspected to see that it is adequate and in good working order.

m. Drivers of motortrucks and those in charge of convoys will be carefully instructed and thoroughly informed regarding safety regulations covering the transportation of explosives and other dangerous articles.

n. Danger flags and placards will be used on all trucks as required by Army regulations.

SECTION VII

SURVEILLANCE, INSPECTION OF SMOKELESS POWDER AND MAINTENANCE, SALVAGE AND DESTRUCTION OF EXPLOSIVES AND AMMUNITION

58. General.—*a.* This section contains general safety requirements and outlines of approved practices for surveillance of explosives, inspection of smokeless powder, and maintenance, salvage, and destruction of explosives and ammunition. Detailed procedure for inspections and tests will be found in appropriate field service bulletins and inspection manuals.

59. Surveillance.—*a.* The term "surveillance" as used herein includes the observation, inspection, investigation, and test of explosives and ammunition in storage and use; inspection of containers and buildings in which they are stored, and the inspection of facilities and methods used in storing, handling, shipping, maintaining, renovating, salvaging, and destroying explosives and ammunition.

b. The purpose of surveillance is to detect in stores of explosives and ammunition all conditions tending to increase deterioration or danger; to determine the state or nature of deterioration and the degree of serviceability, and to segregate seriously unstable munitions.

c. The Chief of Ordnance exercises general supervision over the surveillance of all explosives and ammunition in storage and service; prescribes the tests, technical methods of inspections to be made; and maintains records of the condition of all lots in service and storage.

d. The commanding officer of an ordnance establishment is responsible to the Chief of Ordnance that all ammunition and explosives at his establishment are subjected to proper surveillance; that the results of surveillance tests and inspections are promptly reported; that the Chief of Ordnance has a record by lot number of the condition of all ammunition and explosives on hand.

c. Ammunition inspectors are personnel trained in the surveillance of explosives and ammunition. They are appointed and assigned by the Chief of Ordnance, but are under the control and supervision of the commanding officer.

60. Stability tests of smokeless powder.—*a.* Any nitrocellulose powder will gradully decompose at high temperatures, and as the temperature increases above 70° F., the rate of decomposition increases with corresponding rapidity. At ordinary temperatures, such as are found in magazines, the decomposition of serviceable powder is very slow; but it may be expected that any smokeless powder will deteriorate in the course of time. As decomposition proceeds, the ballistic qualities of the powder become impaired, and decomposition gradually continues to the point where spontaneous ignition may occur.

b. In order to estimate the remaining life of smokeless powder so that it may be used while still serviceable; and to insure withdrawal of powder from service before it becomes dangerously deteriorated, it is necessary to conduct periodic inspections and tests to determine stability or degrees of serviceability. Such inspections and tests are prescribed by the Chief of Ordnance field service bulletins or by specific instructions, as conditions may require.

c. All personnel engaged in the inspection of smokeless powder must be familiar with the characteristics of decomposing powder. Failure to detect a single container of deteriorated powder may result in loss by fire of an entire magazine and its contents.

61. Maintenance.—*a.* Maintenance comprises the activities of reconditioning and renovation. The term "reconditioning" as used in this manual applies only to ammunition and explosives, and includes such current maintenance operations as removing rust, repainting, re-marking, and repacking in new or other serviceable containers. The term "renovation" includes those maintenance operations necessary to restore to serviceable condition an article which has deteriorated and cannot be made serviceable by current reconditioning operations. It usually involves replacement of some deteriorated components.

b. Some of the more common reconditioning operations such as resealing boxes and containers and replacing gaskets may be accomplished in routine operations. Repainting, re-marking, and repacking will be done in accordance with specific instructions from the Chief of Ordnance.

c. The renovation of a lot of explosives or ammunition will not be undertaken except in accordance with the specific directions of the Chief of Ordnance. The work usually involves the use of special equipment and methods, and requires close supervision to maintain adequate standards of safety as well as to assure the desired quality of workmanship.

62. Salvage.—*a.* The term "salvage," as used herein, includes the operations necessary to disassemble or break down ammunition and ammunition components in order to recover therefrom all materials or components which are or may be made serviceable, or which may have a money value as scrap.

b. Salvage operations are conducted in accordance with specific instructions from the Chief of Ordnance.

63. Special safety regulations for maintenance and salvage.—*a.* In maintenance and salvage operations, applicable regulations as given in paragraph 7 will be observed. Regulations which apply particularly to maintenance and salvage of explosives or ammunition are as follows:

(1) Ammunition or explosives will not be reconditioned, renovated, or salvaged within the magazine area unless the site, buildings, or cars in which the work is done are devoted exclusively to such work, and are specifically approved by the Chief of Ordnance.

(2) The quantity of explosives or ammunition involved or present at any operation at one time will be the minimum quantity necessary to carry out the operation.

(3) Maintenance and salvage operations will be carried out in conformity with the quantity-distance requirements of section V.

(4) Placards showing the maximum amount of explosives or ammunition, and the maximum number of persons permitted at or near each operation, will be conspicuously posted. These limits will be strictly observed.

(5) Hazardous operations, such as those involving the removal of boosters from shell, and the disassembly of fuzes and grenades will be barricaded to reduce operating hazards.

(6) Ample fire-fighting facilities will be inspected regularly and maintained in good working order. Buildings and facilities will be protected from grass fires by adequate fire breaks.

(7) Broken boxes, loose powder or explosives, waste paper, and other combustible materials will not be permitted to accumulate.

(8) The layout and construction of renovation plants shall be in conformity with the safety standards prescribed in section XXI for manufacturing and loading buildings.

64. Destruction of explosives and ammunition.—*a*. Explosives and ammunition which are dangerously deteriorated or which cannot be economically salvaged will be destroyed. Destruction of explosive material will be accomplished by burning, exploding, or dumping at sea as specified in following paragraphs of this section. Burying explosives or ammunition, or dumping them into waste places, pits, wells, marshes, shallow streams, or inland waterways is prohibited except as may be authorized under the provisions of paragraphs 66*a* and 259*d* for black powder and chemical ammunition.

b. Destruction will not be undertaken without prior approval of the Chief of Ordnance in each case, except that commanding officers may order the immediate destruction of dangerously deteriorated explosives or ammunition when in their opinion such action is necessary to protect life or property. When destruction is authorized, the provisions of Army Regulations 35-6640, Lost, Destroyed, Damaged, or Unserviceable Property, will be observed.

c. Instructions for destroying duds are incorporated in appropriate technical and field manuals.

d. The methods prescribed for the destruction of chemical ammunition are contained in part IV of this manual under special rules for the various classes of chemical fillers.

65. Special safety regulations for the destruction of explosives and ammunition.—*a*. All dry grass, leaves, and other combustible materials will be removed within a radius of 200 feet from the point of destruction. Fire-fighting facilities for combating grass fires should be maintained readily available and, if practicable, the ground at the point of destruction should be wet down with water at the close of each day's operations.

b. Explosives and ammunition will not be destroyed by detonation if magazines and other buildings are in danger of being dam-

aged by fragments or shock. If the distance from the place of destruction to magazines or buildings is less than 800 yards, a pit or trench which will limit effectively the range of fragments will be used.

c. Demolition of explosives may be accomplished either by the use of electric blasting caps with hand exploders (blasting machines) or by nonelectric blasting caps and safety fuse.

d. The signal for detonation will be given by one designated responsible individual only, who before each detonation will insure that all persons in the vicinity are protected by substantial cover, or have reached a safe distance. If a blasting machine is used, the wires will not be connected to the terminals until all personnel have reached cover.

e. If nonelectric blasting caps and miners' safety fuse are to be used the fuse will be first tested as follows: A piece of fuse 12 inches long will be cut from the roll to be used and burned to determine the approximate time rate of burning in order that sufficient length of fuse will be used to permit all personnel to retire to a safe distance. The rate of burning of fuse varies with atmospheric conditions, degree of tightness of tamping, etc. Fuse which is too large in diameter to enter the blasting cap without forcing will not be used.

f. Electric blasting caps are exploded by an electric current. Nonelectric blasting caps are exploded by flame or sparks from safety fuse. Both types of caps are copper cylinders loaded with very sensitive and violent explosives and must be handled with extreme care. The use of improvised methods for exploding blasting caps is prohibited.

g. One-half pound TNT blocks, one-quarter pound or one-half pound blocks of nitrostarch explosives are provided for demolition purposes. These blocks must not be broken into smaller pieces.

h. Material to be burned will be always removed from containers as attempts to burn certain explosives or ammunition under even slight confinement may result in explosions.

i. The amount of material to be destroyed at one time will be kept at the minimum consistent with reasonable and safe operation. The number of units that may be destroyed safely at one time will be determined carefully by starting with a limited number and then gradually increasing that number until the maximum which can be destroyed without risks to life and property is determined.

j. As some types of ammunition are rather difficult to explode, a search of the surrounding grounds should be made after each blast and any dangerous material which has been thrown from the pit and not detonated should be collected and destroyed.

k. Material awaiting destruction will be protected against accidental ignition or explosion from fragments, grass fires, or burning embers. The base of supplies should be so isolated that if explosives should burn or detonate prematurely, surrounding property will not be damaged.

l. In repeated burning operations, care will be taken to guard against material being ignited from burning residue or heat retained in the ground.

m. Sufficient and suitable protection for personnel must be provided in the form of temporary or permanent barricades, depending on local conditions. Necessary action will be taken to insure that barricades are used and safety distances observed by all persons. In cases of misfire, personnel will not approach the pit, trench, or point of detonation until a period of 30 minutes has elapsed.

n. The destruction of ammunition by explosion or detonation requires very careful control by those in charge. Such work will not be attempted with inexperienced or untrained personnel. The number of employees engaged in such operations will be maintained at the minimum consistent with safety.

o. In the absence of specific regulations or information covering any phase of the destruction of explosive material, instructions will be requested from the Chief of Ordnance.

p. At establishments which are located near a deep-sea waterway, and which are too restricted in area to make burning or detonating safe, explosives or ammunition to be destroyed may be placed on barges, towed out to sea, and thrown overboard. In this case, however, the port authorities will be consulted, and their regulations regarding the transfer and disposal of material of this nature will be observed. The material will be removed from containers before being dumped overboard. Instances are on record in which ammunition thrown overboard in heavy containers has washed up on shore from great distances and depths.

66. Destruction of specific materials.—*a. Black powder.*—The safest method of destroying black powder is to dump it into a stream or body of water; but if no suitable body of water is convenient, it may be burned. In opening containers, safety tools only will be used. The contents of one container only will be burned at one time. The powder must be removed from the container and spread out on the ground in a trail about 2 inches wide, care being taken that no part of the trail parallels another part at a distance of less than 10 feet. A train of inflammable material, such as excelsior, should be used to ignite the powder. Emptied containers will be washed out, as serious explosions have occurred with supposedly empty black-powder cans.

b. Bulk high explosives.—Bulk high explosives such as TNT, explosive D, and tetryl should be destroyed by burning. The explosive to be burned will be removed from containers and spread in layers not over 3 inches thick upon a layer of combustible material such as excelsior. A train of this material should be used to ignite the explosive. Not more than 500 pounds will be burned at one time. Applicable safety regulations contained in paragraph 84 will be observed. If it becomes necessary to destroy other explosives, such as fulminate of mercury or dynamite, special instructions will be furnished by the Chief of Ordnance.

c. Smokeless powder.—Smokeless powder may be destroyed with safety by burning, if the powder is removed from containers and spread out on bare ground in a train. The train should be limited in width and thickness, depending upon the granulation and type of the powder. Safe dimensions are determined by starting with a small quantity and increasing this progressively until the maximum quantity which may be safely burned at one time is reached. A train of combustible material about 25 feet long on the windward side should be used to ignite the powder. General safety regulations contained in paragraph 95 will be observed.

d. Propelling charges.—(1) Separate loading propelling charges should be removed to the burning ground to be destroyed. Bags will be cut open carefully. The smokeless powder will be properly spread, and burned as described in paragraph *c.*

(2) The igniters will be destroyed by first cutting the pads open and removing the black powder. The powder then will be destroyed as prescribed in paragraph 66*a*. The empty powder bags, including the empty igniter pads, will be disposed of by burning in small quantities.

e. Artillery shell.—The following procedure refers to separate loading shell. Fixed ammunition rarely deteriorates to such an extent that it must be destroyed rather than salvaged, but where such action is necessary, shell disassembled from fixed rounds will be destroyed in the same manner as prescribed below for separate loading shell.

(1) When an artillery range or similar large area is not available for the safe destruction of separate loading shell by detonation a pit or trench about 4 feet deep should be used. By covering the shell with 2 or more feet of earth the range of frangments may be reduced.

(2) The projectile to be destroyed is placed on its side in the pit and the required number of demolition blocks as prescribed in the following table will be placed in intimate contact with the side of the projectile and held in position by earth packed around the projectile.

(3) The following table indicates the number of demolition blocks which should be sufficient to destroy shell of the calibers shown.

Caliber of shell	*Number of demolition blocks*
37-mm. and 2.24-inch	1
2.95-inch, 75 mm., 3-inch	2
4.7-inch, 155 mm., 6-inch	3
8-inch, 9.2-inch, 240 mm	8
10-inch, 12-inch, 14-inch, 16-inch	5–6

(4) After the last shot the ground in the vicinity will be searched for any unexploded material. Any such material found will be destroyed by repeating the operations outlined above.

(5) The general safety regulations for the destruction of ammunition given in this manual will be complied with.

f. Bombs.—Bombs should be destroyed in accordance with instructions set forth in paragraph *e*, for destroying artillery shell. However, demolition bombs have such thin walls, contain so much more explosive than artillery shell of corresponding weights, and usually detonate so completely that extreme precautions must be taken to avoid structural damage to buildings and injury to personnel. The destruction of bombs larger than 100-pound bombs should not be undertaken without the specific approval of the Chief of Ordnance. Bombs in the immediate vicinity awaiting destruction should be segregated in small piles 100 feet or more apart and at least 300 feet from the detonating

pit. Extreme precautions must be taken to protect bombs awaiting destruction against accidental initiation by fire, fragments, or propagation.

g. Light mortar shell.—Light mortar shell should be destroyed in accordance with instructions for destroying artillery shell as set forth in paragraph *e*. However, light mortar shell contain a larger bursting charge than artillery shell of the same caliber and have relatively thin walls. Care will be taken to limit the number destroyed at any one time and to protect shell awaiting destruction from flying fragments.

h. Small-arms ammunition.—Small-arms ammunition should be destroyed in a pit which is approximately 6 feet square and 4 feet deep. An inclined chute, such as a piece of pipe, should be provided, and this chute should be placed so that one end is over the center of the pit and the other behind a barricade. Precautions should be taken to baffle the open end behind a barricade, or locate it so that the operator cannot look down the pipe. A hot fire should be built in the pit and then the pit should be covered with a piece of sheet iron or other suitable material to confine flying fragments. Cartridges should be fed into the fire through the pipe. Care should be taken to prevent an accumulation of unexploded ammunition in the pit.

i. Fuzes, detonators, adapters, boosters, etc.—(1) Loaded components, such as artillery fuzes, grenade fuses, boosters, detonators, and similar material, except primers, may be destroyed either by burning or by exploding. In the destruction by burning these components will be destroyed one at a time in the same manner as outlined above for small-arms ammunition.

(2) In accomplishing the destruction of these components by explosion a small number of components, depending upon the type and kind, should be placed in an open container in a pit or trench about 4 feet deep. On top of each container, and in intimate contact with them, should be placed one or more demolition blocks to be exploded with electric blasting caps or with blasting caps and safety fuse, observing the safety precautions outlined in paragraph 65.

j. Primers.—(1) In the destruction of primers, except 100-grain or 110-grain primers, a trench approximately 2 feet deep, 1 foot wide, and of sufficient length to accommodate the number of primers to be burned at one time, should be prepared with a quantity of excelsior or similar combustible material sufficient to insure a hot fire throughout its length. The primers should be removed from boxes and placed on the excelsior before the fire is lighted. Pasteboard cartons need not be opened before they are placed in the trench. A piece of sheet metal should be placed over the trench, to confine fragments as much as possible. Sufficient space should be left to allow a draft through the trench. After the primers and cover are in place, a train of combustible material leading into the pit should be prepared and lighted. Personnel should then take cover or withdraw to a safe distance.

(2) Large primers, such as 100-grain and 110-grain primers are subject to explosion en masse if destroyed in large quantities by burning. These types should be destroyed as described in subparagraph *h* above, except that only one primer will be dropped down the chute, and the operator will wait until it has exploded before introducing another primer into the chute.

(3) The stock of primers awaiting destruction will not be allowed within 300 feet of the burning operations, and great care will be taken to protect the pile from accidental ignition by flying fragments or sparks. This stock will be limited to a day's supply. Other applicable regulations, contained in paragraph 65 will be strictly observed.

k. Grenades.—Fragmentation grenades may be destroyed by explosion in a manner similar to that prescribed for separate loading projectiles. Quantities of not more than 20 grenades will be piled in close contact in the pit. Three demolition blocks placed on top of the pile should be sufficient to accomplish destruction.

l. Pyrotechnics.—Pyrotechnics, except parachute flares and photoflash bombs, will be destroyed by burning in a pit in a manner similar to that prescribed for primers. Parachute flares will be destroyed by burning on the ground in the open. Individual flares should be separated by a distance of at least 4 feet and placed on top of a layer of combustible material. After lighting the train of combustible material, personnel should take cover or withdraw to a safe distance. Photoflash bombs will be destroyed as prescribed in paragraph 66*c* for artillery shell.

PART II

SPECIAL REGULATIONS FOR HANDLING AND STORING SPECIFIC KINDS OF MILITARY EXPLOSIVES AND AMMUNITION, TOGETHER WITH BRIEF DESCRIPTIONS OF THE PROPERTIES AND USES OF THE MORE IMPORTANT ITEMS

Section VIII

BLACK POWDER

67. General.—*a.* Black powder is regarded as one of the worst known explosive hazards. When ignited unconfined it burns with explosive violence, and will explode if ignited under even slight confinement. It can be ignited easily by very small sparks, heat, and friction.

b. Army black powder is classed as a low explosive. It is a black, granular, mechanical mixture of potassium nitrate, charcoal, and sulphur. When glazed with graphite it has a bright, polished appearance. It is subject to rapid deterioration in the presence of moisture, but if kept dry retains its explosive properties for many years.

c. Each lot has certain characteristics and properties which make it necessary to maintain carefully the identity of all powder in the lot. A history of the manufacture of each lot is filed in the office of the Chief of Ordnance and is used to investigate any unusual action or deterioration occurring in service or in storage.

d. Army black powder is used for the ignition of smokeless powder propelling charges, airplane flares, and bursting charges of hand grenades; as a bursting charge in shrapnel, practice bombs, and practice trench-mortar shell; in saluting charges, smoke-puff charges, time and percussion fuzes, pellets, primers, and primer-detonators; and in expelling charges of pyrotechnic signals.

68. Grades.—*a.* Army black powder is designated by one grade of five granulations designated by numbers, in accordance with the provisions of United States Army Specification No.

50–14–1, Army Black Powder. The uses of the granulations are substantially as follows:

Designation	Typical uses
Army black powder:	
Grade A, No. 1 . . .	All igniting charges, certain primers, and saluting charges.
Grade A, No. 3 . . .	Special uses.
Grade A, No. 4 . . .	Base charges for shrapnel, base charges for fuzes, primers, smoke-puff charges, bursting charges for practice bombs, practice loaded projectiles, and certain subcaliber shell.
Grade A, No. 5 . .	Pellets for primers and fuzes.
Grade A, No. 6 . .	Pellets for primers and fuzes.

Granulations No. 1, No. 3, and No. 4 are glazed; No. 5 and No. 6 are unglazed.

b. The above grades are strictly Army designations and should not be confused with commercial grading. Commercial grades are indicated by the following abbreviations:

Potassium-nitrate powders, A powders.

Sodium-nitrate powders, B powders.

UG, unglazed; G, glazed; C, coarse; F, fine.

Thus, the designation AFFFG means a commercial potassium nitrate, glazed powder of triple F granulation (very fine), which is about the same size as Army grade A–4.

c. Time fuze powder is covered by United States Army Specification No. 50–14–6 (latest revision), Fuze Powders. Two types of time fuze powders are listed: Types I and II, which are blended to obtain the desired rate of burning for any fuze.

d. Sodium nitrate black powder is substituted in some cases for Army black powder because of its relatively lower cost. It is covered by United States Army Specification No. 50–14–4 (latest revision), Sodium Nitrate Black Powder. The specification covers one grade as follows:

Class A: For use in saluting charges.

Class B: For use in practice bombs.

Sodium nitrate black powder is more hygroscopic than Army black powder. Sodium nitrate black powder pellets are used in blank ammunition for cannon, and in practice shell. Specifications covering the pellets may be found on current Ordnance drawings.

69. Packing and marking.—*a.* The standard container for Army black powder is a metal keg of 25 pounds capacity built in accordance with Ordnance specifications, or a commercial drum

of equal quality and capacity complying with Interstate Commerce Commission regulations.

b. Black powder in the form of igniting charges may be packed in airtight, metal-lined containers, complying with Interstate Commerce Commission regulations; but the amount of black powder packed in one container is limited to 50 pounds.

c. In addition to the marking prescribed by Interstate Commerce Commission regulations the following identifying data should appear on Army black powder containers:

(1) Ordnance contract number.

(2) Manufacturer's name.

(3) Plant symbols or key letter.

(4) Name and grade of material.

(5) Army lot number.

(6) Net weight and gross weight.

70. Storage and shipping.—*a.* Ordnance drawings show the recommended method of piling black powder in metal containers. This method will be followed when new stocks are received or existing stocks are repiled.

b. When black powder is shipped or received, each container will be inspected for holes and weak spots. They will be examined particularly for small holes, such as those made by nails, which are visible only upon close examination. Damaged containers will not be repaired; the contents will be transferred to new or serviceable containers.

c. Metal containers for export shipment will be crated. Usually two containers are packed in each crate.

71. Maintenance.—*a.* Repainting of containers and repacking of black powder contained in damaged or unserviceable containers constitute the principal maintenance activities. Black powder containers are subject to sweating, which rusts metal drums or kegs, so repainting is necessary to keep containers serviceable. Repainting will not be done in a magazine in which explosives or ammunition are stored. It may be done in a nearby empty magazine, or in clear weather in the open at least 100 feet from the nearest magazine. The quantity of black powder at or near such operations will be limited to 100 pounds. The marking on repainted containers will be checked carefully to see that it is a facsimile of the old.

b. The metal caps on certain types of black powder containers deteriorate in storage. Replacement of these caps is allowed, but the same safety precautions as outlined above for repainting containers will be followed.

c. Operations such as the removal of black powder from containers and its transfer from unserviceable to serviceable drums will be conducted in strict compliance with applicable portions of the safety regulations for black powder charges, as described in the following paragraph.

72. Black powder charges.—*a*. The assembly of blank ammunition for cannon and saluting charges will be conducted in accordance with special instructions furnished by the Chief of Ordnance.

b. Blank ammunition may be loaded with either:

(1) Army black powder in bags.

(2) Sodium nitrate black powder in bags.

(3) Sodium black powder in pellet form.

Sodium nitrate black powder is available commercially and at a cost somewhat less than Army black powder, which contains potassium nitrate. Commercial sodium nitrate black powder pellets wrapped in cellophane are being used extensively. The pellet form of this powder greatly facilitates loading and reduces assembly hazards. Pellets are supplied in single and double units for reduced and full charges, respectively. Because sodium nitrate black powder is more hygroscopic than Army black powder, additional care is necessary in storing and handling to prevent exposure to moisture.

c. Precautions similar to those applying to the assembly of other ammunition will be followed in assembling blank ammunition and saluting charges. Particular caution must be exercised because of the treacherous nature of black powder. The following general safety regulations will be complied with in the assembly of black ammunition and saluting charges:

(1) Black powder operations should be conducted in special buildings which will not be used for other purposes at the same time.

(2) The floor of the building in which black powder is handled will be surfaced with suitable material.

(3) Intraplant quantity-distance requirements for high explosives as given in this manual will be followed.

(4) Absolute cleanliness will be maintained at all times in and around each operation.

(5) Noninsulating safety shoes will be worn by personnel in all assembly operations.

(6) All equipment will be electrically grounded, and it should be determined by test that all parts of the equipment are effectively grounded.

(7) Empty metal containers which have held black powder will be thoroughly washed inside with water before they are disposed of. Serious explosions have occurred with supposedly empty cans. Wooden containers will be destroyed by burning.

(8) Safety tools only will be used in opening or closing containers or in handling black powder.

(9) Processes should be so laid out as to bring about frequent grounding of operators.

73. Fires.—*a*. Most black powder fires start from sparks, and ignition results in an explosion so quickly that no attempt can be made to fight the fire. Every effort will be made to prevent fire from reaching stores of black powder, but if this fails, fire-fighting forces will be withdrawn at least 800 feet from the fire, and will protect themselves against an explosion by seeking any cover available, or by lying flat on the ground.

b. If an explosion should occur, every effort will be made to prevent flames from spreading to adjacent magazines. Fire-fighting forces must be cautious in approaching a fire which may involve black powder to avoid being trapped or injured by an explosion.

74. Safety precautions.—*a*. Most explosions of black powder originate from sparks, and the safety rules contained in the following paragraphs will be strictly enforced and obeyed.

b. A container will not be opened in a magazine in which explosives or ammunition are stored. This will be done only in a room or building free from all other explosives or ammunition, or in suitable weather in the open at least 100 feet from the nearest magazine. The quantity at or near such an operation will be limited to 100 pounds.

c. Safety tools only will be used in opening or closing containers, or in other operations involving black powder.

d. Safety shoes will be worn in all rooms in which black powder is handled, and by all persons engaged in handling black powder; the wearing of nonconductive shoes such as rubber is prohibited.

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c. If the handling of black powder is carried on over a concrete floor, the floor will be covered with a tarpaulin, or other suitable material.

f. Loose black powder is extremely dangerous. Whenever it is necessary to handle loose black powder not over 50 pounds of powder in open containers and 50 pounds in closed containers will be permitted at or near such operations.

g. If black powder is spilled on benches or floors all work will be stopped until the powder has been removed and the explosive hazard of any remaining dust or fine particles has been neutralized with water.

h. Rooms or buildings in which black powder is handled will be inspected frequently for the presence of black-powder dust; and all such dust will be immediately removed with water.

Section IX

HIGH EXPLOSIVES

75. General.—*a.* Trinitrotoluene (TNT), ammonium picrate (explosive D), tetryl, picric acid, and ammonium nitrate may be stored in large quantities at Ordnance establishments. The storage, in small amounts, of such materials as mercury fulminate and lead azide will be governed by the provisions stated for such materials in section XXII, Storage and Handling of Hazardous Raw Materials, Explosives and Inflammables. When it is necessary to store substantial amounts (more than a few pounds) of these latter explosives, or of explosives not covered in this section IX, special regulations will be furnished by the Chief of Ordnance as required.

76. TNT.—*a.* Trinitrotoluene, as stored in bulk, is in the form of flakes or small crystals varying in color from buff to brown. It is very stable, and does not form sensitive compounds with metals. It ignites by friction, shock, or spark, and burns readily like a tar or resin. If burned in large quantities it may detonate.

b. TNT is used in boosters, as the bursting charge of shell and bombs, in some primer mixtures, and for demolition blocks. When combined with ammonium nitrate, the resulting explosion mixture is known as amatol. This mixture is designated as 50–50 amatol or 80–20 amatol, depending upon the approximate proportions of ammonium nitrate and TNT respectively.

c. A lot of TNT usually ranges from 5,000 to 100,000 pounds. As each lot has definite characteristics its identity must be carefully maintained. A history of the manufacture of each lot is filed in the office of the Chief of Ordnance and is used in the investigation of any unusual action or deterioration occurring in service or in storage.

d. TNT is graded in accordance with United States Army Specification No. 50–13–5.

77. Explosive D.—*a.* Explosive D (ammonium picrate) is a high explosive which in bulk appears in the form of finely divided crystals varying in color from yellow to orange-brown. It stains the human hair and skin yellow. Explosive D is less sensitive than TNT, is highly inflammable, and may be ignited by friction, heat, or sparks. It can be exploded by severe shock, friction, or heat and may detonate on burning. It reacts with lead and some other metals to form sensitive picrates, but in this respect is less active than picric acid.

b. Explosive D is used as a bursting charge for all projectiles which must withstand severe stresses and shocks before detonating; such as armor-piercing projectiles.

c. Ammonium picrate which has been pressed at a shell-loading plant and removed from shells is much more sensitive to shock than new material. If it becomes necessary to store this material, special precautions should be observed in protecting it against shock or fire. Preferably, it should be stored in a building by itself.

78. Ammonium nitrate.—*a.* Ammonium nitrate is a crystalline powder varying in color from almost white to brown. It is mixed with TNT in the manufacture of amatol, which is used primarily as a bursting charge in demolition bombs. Ammonium nitrate usually can not be detonated by heat or friction but may be exploded by a sufficiently heavy initiation. It may be exploded by relatively light initiation if it has been sensitized by certain impurities, among which are many carbonaceous materials. Ammonium nitrate is not very inflammable at atmospheric temperatures, but fires involving ammonium nitrate in large quantities become an explosive hazard.

b. When stored in approved metal containers in a high explosives storage area the quantities and distances for high explosives storage will be complied with. When stored in an area with inflammable materials, which area is separated from buildings containing high explosives by inhabited building distances as set forth in section V of this manual, ammonium nitrate may be stored in accordance with the safety-distance regulations for smokeless powder.

c. The standard container for ammonium nitrate is a moisture-proof metal container approved by the Ordnance Department and complying with Interstate Commerce Commission regulations. Each container must be marked as prescribed by United States Army Specifications.

79. Tetryl.—*a.* Tetryl is a yellow crystalline powder. It burns readily and is more sensitive than TNT. It ignites from friction, shock, or sparks, and is quite likely to detonate if burned in large quantities. Special precautions must be taken to prevent ignition or explosion from friction or blows due to rough handling.

b. Tetryl is used in loading boosters and the booster cavities of fuzes. Lots of tetryl are limited to a maximum of 50,000 pounds. The history of each lot is recorded as for TNT.

80. Packing and marking.—*a.* The containers used for packing bulk high explosives will comply with Interstate Commerce Commission regulations, and Ordnance drawings and specifications. All containers must be lined with strong sift-proof cloth or paper bags, or liners with cemented seams and closures. In addition to the markings prescribed by Interstate Commerce Commission regulations, the following identifying data should appear on the container: Ordnance contract number, place, and date of manufacture, lot number, name, and grade of material, and net weight.

81. Storage.—*a.* Containers of high explosives will be stored with the top side up to prevent the explosive from sifting out,

new stocks will be piled, and existing stocks rearranged in compliance with applicable Ordnance Department drawings.

82. Maintenance.—*a.* High explosives are usually very stable in storage, but their containers are subject to deterioration. Damaged or deteriorated containers will be repaired, or their contents transferred to new or serviceable containers. This work will be done in a room or building free from all other explosives or in suitable weather in the open, at sufficient distance to comply with quantity-distance tables requirements, but in no case closer than 100 feet from any building containing explosives or ammunition. The amount of explosives at or near such operations will be limited to one open container of 100 pounds and four closed containers. Safety tools will be used for all repacking or repairing operations. The contents of damaged containers will be examined for the presence of dirt or foreign matter, which must be removed before repairing or repacking.

b. If a standard container is not available for repacking, a strong wooden box not exceeding 140 pounds gross weight when packed will be used. Such containers will be lined carefully as specified for the standard container. Containers will be marked to comply with Interstate Commerce Commission regulations.

83. Fires.—If a fire occurs in explosives stored in wooden boxes, the explosives usually will burn quietly, but may detonate. If the fire has gained considerable headway before it is discovered, no attempt should be made to fight the fire. The magazine should be abandoned and the efforts of fire-fighting forces should be directed toward preventing the spread of fire to other magazines. Fire-fighting forces will not go closer than adjacent magazines, and will protect themselves against a possible explosion by taking advantage of available cover, or by lying flat on the ground.

84. Safety precautions.—Safety shoes will be worn in repacking rooms or buildings, and whenever loose high explosives are handled. The wearing of safety shoes by personnel handling high explosives in boxes or other containers is at the discretion of the commanding officer, who should be guided in his decision by existing conditions. Boxes containing high explosives will be opened and repaired with safety tools. Containers will not be opened in a magazine in which explosives or ammunition are stored.

SECTION X

SMOKELESS POWDER

85. General.—*a.* A complete description of the manufacture and properties of smokeless powder will be found in TM 9-2900, Military Explosives. Only those properties which are important from a storage and surveillance standpoint are outlined herein.

b. Smokeless powder is designed to contain a definite percentage of residual volatiles in the finished grain. It is essential that this percentage remain as constant as possible during the time the powder is in service or storage. Any change in the percentage of volatiles affects the ballistics and stability of the powder, so it is packed in airtight containers. When a container of nitrocellulose powder is opened, an odor of ether and alcohol will be noted, which is a normal condition.

c. Small amounts of unconfined smokeless powder burn with little smoke or ash and without explosion. When confined, or in large quantities, the rate of burning increases with the temperature and pressure. Under certain conditions, with sufficient initiation, smokeless powder has been known to detonate.

d. Salvaged or deteriorated smokeless powder must be shipped under water in containers such as boxes, barrels, or tank cars which comply with the Interstate Commerce Commission regulations.

86. Cannon powder.—*a.* Service smokeless powder forms the propelling charge for fixed and separate loading ammunition used in all Army cannon. Propelling charges are ignited by a primer containing a charge of black powder or a primer and an igniter charge of black powder.

b. Smokeless powder for cannon, in lots of approximately 100,000 pounds, is manufactured under uniform conditions,

grained to a uniform size, and blended to contain a uniform amount of residual volatiles. The characteristics and properties peculiar to each lot require that its identity be maintained carefully until it is used or withdrawn from service. For each lot there is prepared and filed in the office of the Chief of Ordnance a description sheet which contains the details of manufacture and all chemical and physical tests made on the raw materials and finished powder. These sheets are supplemented by reports of ballistic tests made in proof firing the lot of powder, and establishing the weight of charge. These records are referred to in making investigations of unusual results, abnormal deterioration, or other difficulties encountered or noted in service or in storage.

87. Small-arms powder.—*a.* Several kinds of smokeless powders have been authorized for use in small-arms ammunition. Many of these are coated with graphite and have a black polished appearance. The powder grains are very small, and ignite more readily and burn freely than cannon powder. When moisture is present, or abnormal temperatures prevail, they are subject to more rapid deterioration than larger grains. Some small-arms powders are nearly as sensitive to friction as black powder. Special precautions should be taken to avoid friction when these powders are handled, and particular attention should be given to spilled powder in operating lines.

b. Small-arms powders are used as charges in all small-arms ammunition such as ball, tracer, incendiary, armor-piercing, and blank ammunition used in rifles, machine guns, automatic rifles, pistols, and revolvers. They are also used in propelling charges for trench-mortar ammunition, 37-mm. cannon, and in blank cartridges for grenades and pyrotechnics. Small-arms powder lots are smaller than cannon powder lots, varying in size from a few thousand pounds up to approximately 60,000 pounds. Lots of pistol powder are much smaller than those of rifle and machine-gun powders. The identity of small-arms powder lots is maintained as for cannon powders, and similar description sheets are prepared.

c. Most small-arms powders can be grouped into two general classes: nitrocellulose or single-base powders, and nitroglycerine or double-base powders. The following are brief descriptions of most types of small-arms powders now in service. More detailed information concerning small-arms powders is given in TM9-2900, Military Explosives.

d. Single-base or so-called "straight nitrocellulose type":

(1) *E. C. powder* (*Explosives Co. powder*).—This powder is granulated into small shot-like grains, pink or yellow in color. It is used in caliber .30 and caliber .50 blank ammunition, and as a bursting charge for grenades.

(2) *Pistol powder No. 5.*—This powder is used in caliber .45 ball cartridges fr pistol and revolver. It is made in the form of round flakes.

(3) *IMR 1185.*—This is a coated nitrocellulose powder, containing powdered tin, or tin salts. It is made in the form of cylindrical monoperforated grains, and is used in caliber .30 ball M1, caliber .30 tracer M1, and caliber .30 armor-piercing M1 ammunition. Until 1941 it was used in caliber .30 ball M2 ammunition. It is now superseded by IMR 4676.

(4) *IMR 4676.*—This is coated nitrocellulose powder made in the form of cylindrical monoperforated grains of shorter length than that of IMR 1185. It contains no tin, but a small proportion of potassium salts for flash elimination. It is used in caliber .30 ball M2, caliber .30 armor-piercing M2, and caliber .30 tracer M1 ammunition.

(5) *IMR 4166.*—This is coated nitrocellulose powder made in the form of cylindrical, monoperforted grains, containing both tin and potassium compounds. It is used in caliber .50 ball, armor-piercing, and tracer ammunition.

e. Double-base, or nitroglycerine type:

(1) *Bulls-eye powder No. 2.*—This was used in caliber .45 pistol ball and tracer ammunition. Its use has been suspended.

(2) *HiVel No. 6.5.*—This is coated powder made in the form of cylindrical monoperforated grains, containing about 20 percent nitroglycerine. It was used in loading about 4 million rounds of high velocity armor-piercing caliber .30 ammunition.

88. Flashless, nonhygroscopic powder.—*a.* Flashless, nonhygroscopic (FNH) powders are used in small-arms and cannon ammunition. They are similar in appearance and granulation to the older type of straight nitrocellulose, or pyro powder. The only marked difference is the absence of the characteristic odor of ether and alcohol, generally associated with nitrocellulose powder.

b. Flashless, nonhygroscopic powders will be subjected to the same surveillance tests as are prescribed for cannon powder.

The regulations governing this type of powder are the same as those for cannon powder.

89. Nonstandard powder.—At times, powders such as cordite or other nonstandard powders may be stored at Ordnance establishments. These powders are subject to the same safety regulations and surveillance tests as are prescribed for standard powders.

90. Packing and marking.—*a.* Smokeless powder is packed in accordance with the following general rules. Specific requirements for packing are covered in Ordnance drawings, specifications, and directives.

(1) The standard container for multiperforated nitrocellulose powders with web thickness of 0.019 inch and above is an all-steel box of 110 pounds' capacity, constructed in accordance with Ordnance drawings.

(2) Standard containers for most double base powders, single perforated powders, and all powders with web thickness less than 0.019 inch are metal-lined wooden boxes, constructed in accordance with Ordnance drawings.

(3) For temporary storage, or transportation to loading plants, most powders may be packed in fiber containers in accordance with instructions issued by the Chief of Ordnance.

b. In addition to the marking required by Interstate Commerce Commission regulations, the following data should appear on smokeless powder containers:

(1) Initials of the manufacturer whose formula is used.

(2) Type of powder.

(3) Manufacturer's initials.

(4) Lot number.

(5) Year of manufacture.

(6) Caliber of gun for which intended.

(7) Net weight.

91. Storage.—*a.* The methods of piling bulk smokeless powder in boxes are shown on Ordnance drawings. These drawings will be followed when new stock is piled or existing stock rearranged.

b. The stability and useful life of smokeless powder are adversely affected if it is stored in a damp atmosphere or subjected to high temperatures. A combination of the two is particularly bad. Magazines for smokeless powder should be dry and the ground around them should be well drained. They should have a minimum variation in temperature and a free circulation of cool, dry air, except that a free-circulation of air is not ordinarily required for smokeless powder stored in igloo magazines. Small-arms powders in bulk are stored in the same manner as cannon powders. As they may deteriorate more rapidly than cannon powders the selection of proper storage magazines and the maintenance of good storage conditions are most important.

c. Smokeless powder in containers will not be exposed to the direct rays of the sun for any long period of time. Containers which cannot be placed promptly under cover will be covered with a tarpaulin placed so that air can circulate through the pile.

d. Rough handling of smokeless-powder containers is prohibited, as seams may be opened in the containers or liners thus allowing air and moisture to enter the container, creating conditions which may seriously affect the life of the powder.

92. Maintenance.—*a.* The principal maintenance activities are the repair of damaged containers and the replacement of defective covers and gaskets. Containers for bulk powder are not ordinarily air-tested in storage. They are substantially made and should not develop leaks after they have been filled and air-tested, unless they have been subjected to extremely rough handling.

b. Powder will not be stored or shipped in damaged containers. The outer or wood container usually can be repaired or replaced without removing the contents of the inner container. This work will be done in a suitable room or building free from all other explosives or ammunition, or in clear weather, in the open, shaded from the sunlight at sufficient distance to comply with quantity-distance tables requirements, but in no case closer than 100 feet from any building containing explosives or ammunition. Safety tools will be used.

c. When the inner metal container is damaged, or when powder is to be repacked in new or serviceable containers, all repacking will be done in a suitable room or building, free from all other explosives or ammunition, where the powder will not be exposed to a damp atmosphere or the direct rays of the sun. Each container in which powder is to be repacked will be air-tested both before and after it is filled. This will be done with the air-testing apparatus used for testing the containers for separate loading propelling charges, and using a special cover fitted with an air-test hole. The amount of powder at or near repacking operations will be limited to that in one open container and nine closed containers. The distance from nearby buildings containing explosives will be in accordance with the intraplant quantity-distance table, and in no case less than 100 feet. The inner metal container will not be repaired or soldered until precautions have been taken to insure that it contains no loose grains of powder or powder dust. Safety tools only will be used.

93. Fires.—Careful study of the reports of several smokeless powder fires, which have occurred at Ordnance establishments, shows that bulk powder in storage constitutes an unusual and severe fire hazard which in most cases can be confined to the building in which it originates. If a fire is discovered in a magazine, there is little chance that the building can be saved, and the efforts of the fire-fighting forces will be confined to protecting adjacent magazines. Because of the intense heat generated by burning smokeless powder, all fire-fighting equipment must be halted at least 200 yards from the fire, and all available cover utilized by the fire-fighting forces. A careful watch will be maintained for burning embers and grass fires in order to prevent the fire from spreading. If a fire occurs in a magazine or repacking room where employees are working and involves only a small amount of loose powder (not more than 150 pounds), an effort should be made to control and prevent the spread of the fire.

94. Explosion hazards of smokeless powder.—*a.* When smokeless powder is stored in magazines in containers or propelling charges, there is no evidence to indicate that fires will give rise to any unusual hazards. Cases in which pressures great enough to result in structural damage have occurred involved the burning or explosion of smokeless powder under circumstances not ordinarily encountered in the storage of the material in containers. It is known that pressure may develop when powders having web thicknesses of less than 0.010 inch are burned in heavy closed containers. When these powders are burned in standard zinc-lined wooden packing boxes, dangerous pressures do not develop. Similarly, when double base powder or powders of small granulations are burned in uninterrupted columns not exceeding certain established critical heights, dangerous pressures do not develop.

b. There is however incontrovertible evidence that explosions of nitrocellulose powders up to large grain sizes are capable of being propagated from box to box when they are initiated by detonation of high explosives charges.

95. Safety precautions.—*a.* Smokeless powder exposed to extremely adverse conditions of moisture and temperature for a long period of time may ignite spontaneously. Care will be taken to protect powder from excessive temperature and moisture, as such conditions hasten decomposition. It always must be protected from the direct rays of the sun. If powder becomes wet or damp, or if there is any reason to suspect that it has been exposed to moisture, it will be segregated from other powder until it has been found satisfactory by stability tests. When leaking containers are discovered an examination of the contents will be made for the odor of decomposing powder and the evolution of reddish fumes. If any such condition is observed, the powder will be segregated or disposed of in accordance with pertinent Ordnance field service bulletins.

b. Powder will always be stored in containers, but should powder be spilled or powder dust accumulate, it will be removed immediately, as loose powder and powder dust are dangerous fire hazards. Dragging powder boxes over smokeless powder grains has been the cause of serious fires. Extreme care will be taken to guard against powder dropping into cracks and crevices or lodging in places where it may remain over a long period of time without being detected. It is believed that many fires have occurred from this cause.

c. In opening containers or repairing damaged boxes containing smokeless powder, safety tools will be used, and if powder is being repacked, the floor will be covered with tarpaulins, and safety shoes will be worn.

SECTION XI

SEPARATE LOADING PROPELLING CHARGES

96. General.—*a.* The regulations for separate loading propelling charges are similar to those for bulk smokeless powder. Propelling charges contain black powder ignition charges, but because this black powder charge is protected by the cloth bag, and the amount of black powder in the igniting charge is relatively small, the controlling factor in prescribing regulations for storage and handling is the smokeless powder content. Details of the various types of charges are shown on Ordnance drawings.

b. A lot of propelling charges consists of all those made from one lot of powder, and the lot number is the same as the lot number of the powder. Thus it may be possible to have in storage bulk powder and propelling charges bearing the same lot number. The identity of all propelling charges in a lot must be carefully maintained as each lot has certain characteristics, such as the weight of charge, which are different from all other lots.

c. The regulations regarding fires and safety precautions are the same as for smokeless powder in bulk as contained in section X. However, if propelling charges become damaged in such a manner that the igniting charge has been broken, the propelling charge will be handled under the safety regulations prescribed for black powder.

97. Packing and marking.—*a.* The standard container for all separate loading propelling charges or sections of propelling charges, with the exception of those for mobile artillery weapons, is an airtight, cylindrical, metal container designated as a cartridge storage case.

b. The standard container for propelling charges for separate loading mobile artillery weapons is a slip cover fiber container of the type used in packing artillery complete rounds for one or two charges. These containers are similar in size to the metal containers formerly used in packing these charges. Since these containers are not absolutely airtight, they are not provided with test holes for making air tests. Propelling charges in fiber containers are shipped in packing bundles of three containers each, the bundle accessories being similar to those used for packing complete rounds of certain calibers. Holes are provided in the end plates so that each container may be slit for insertion of methyl violet test paper. Fiber containers may be received with each fiber tube inclosed in spiral-wrapped, steel reinforcing tubes.

c. Each metal container is lined with heavy paper. The base ends of all charges and sections of charges, both ends of single section charges and top ends of upper section in each case are protected with a cloth and felt igniter protector cap. Some igniter protector caps are fitted with strips of webbing which extend to the top of the container. They are used to draw the charge out of the container. Metal containers are usually painted gray with black stenciling. Containers in which igniters or empty charge bags with igniters are packed are usually painted gray and striped with red paint.

d. Each propelling charge and each section of a propelling charge has stenciled on it, or on a linen tag firmly attached to it, the data necessary for its identification and proper use. It is the present practice to dye with red color that part of the propelling charge bag which contains the igniter of black powder.

98. Handling and shipping.—Propelling charges are shipped in the containers in which they were originally packed, as these comply with Interstate Commerce Commission regulations. Propelling charges will be handled with care, as rough handling may open seams in the container or loosen the covers. Shipments which are received in a badly damaged condition will be reported in detail to the Chief of Ordnance, and the contents of damaged containers will be examined carefully for moisture or other signs of deterioration before repacking. Every shipment received in metal containers will be promptly subjected to air tests. Propelling charges will not be exposed to the direct rays of the sun for any long period of time. Charges which cannot be placed promptly under cover will be protected with tarpaulins placed so that air can circulate through the pile.

99. Storage.—*a.* Propelling charges packed in metal containers which are protected by wood tops or crates will be stored so that the containers can be readily air-tested. Crates and wood tops removed from containers will be retained and stored for future use, but not in the magazine with the propelling charges.

b. The method of storing propelling charges in fiber or metal containers is shown on Ordnance drawings. These will be followed when new stock is stored, or existing stock is repiled.

c. If propelling charge containers are crated, the crates will be removed before the propelling charges are stored. Fiber containers should be inspected visually to determine that their condition is suitable for storage.

100. Maintenance.—*a.* All metal cartridge storage cases are fitted with test holes and plugs so that they can be air-tested for tightness. Every metal container in which propelling charges are stored will be air-tested for leaks when it is received or

when it is subjected to handling or moving, which may cause leaks. Air-testing will be done with the apparatus, described on Ordnance drawings, or with any similar air-testing device, except that motor-driven air compressors will not be taken into a magazine in which explosives and ammunition are stored. A pressure of 3 to 5 pounds per square inch is used and leaks are detected by noting the variation in the reading of the gauge attached to the air-testing apparatus. All containers which are leaking will be repaired, or the contents thereof will be transferred to serviceable airtight containers. Leaks due to defective covers and gaskets are readily repaired without removing the contents of the container, but leaks in other parts of the container require the removal of the contents before repairs can be made. Damaged containers will not be repaired in a magazine. This work will be done in a nearby empty magazine or in a repacking room or building. The amount of powder at or near repacking or repairing operations will be limited to that in one open container and four closed containers. Safety tools will be used in opening and closing containers. After repacking, each container will be air-tested before it is placed in storage.

b. Defective covers and gaskets may be replaced without removing the container from the magazine in which it is stored, but precautions will be taken to guard against sparks which might cause fire.

c. Personnel assigned to air-testing work will be familiar with the characteristics of decomposing powder. They will examine each container opened for air-test for the characteristic odor of decomposing powder or the evolution of reddish-brown fumes.

d. Metal containers may rust, so they will be repainted whenever such action is necessary to prevent further deterioration. When containers are repacked or repainted, the markings on each container will be reproduced completely. Containers will not be repainted in a magazine in which explosives or ammunition are stored.

e. Propelling charges packed in fiber containers are not subjected to air tests except when they are repacked. Because of the manner in which they are protected during shipment there should be little tendency for these containers to develop leaks. If fiber containers are damaged no attempt will be made to repair them. Their contents will be transferred to serviceable containers.

SECTION XII

SMALL-ARMS AMMUNITION

101. General.—*a.* Descriptions of the various kinds of small-arms ammunition will be found in appropriate field and technical manuals.

b. The size of lot of small-arms ammunition is determined by the quantity which may be manufactured conveniently, inspected, and tested under uniform conditions. An acceptable lot must exhibit uniform characteristics in acceptance tests. It may vary from a few thousand to a million rounds, but averages approximately 500,000 rounds. As each lot has definite characteristics its identity must be maintained. A lot number once assigned remains unchanged until the ammunition is expended.

c. All small-arms ammunition is not divided into lots. Caliber .22 ammunition and other types may not have lot numbers. Lot numbers for shotgun shell are designated as Lot 1, Lot 2, etc., followed by the year of purchase.

d. The term "cartridge lot" as well as "ammunition lot" has been used at times to identify small-arms ammunition. The latter name is preferred. The various systems that have been used in designating ammunition lots of small-arms ammunition are described in applicable technical regulations.

102. Grades.—*a.* Lots of caliber .30, caliber .45, and caliber .50 ammunition designed for target practice or combat use in standard service weapons are assigned to grades representing degrees of serviceability. The grades are determined by ballistic tests, surveillance tests, and reports of performance from the using arms and services. Assignments to grades and changes therein are made by the Chief of Ordnance. A grade is usually assigned to an entire lot, however, portions of the same lot stored under different conditions may develop defects which would not apply to the entire lot. Different grades sometimes may be established for parts of lots at different places. Ungraded ammunition will not be issued or used for any purpose, but will be reported to the Office of the Chief of Ordnance. The grades of ammunition are not marked on packing boxes or on slips inside the box; they are found only in Ordnance field service bulletins.

b. Ammunition which is not used for target or combat purposes is not ordinarily graded; but special tests, both ballistic and surveillance, may be ordered by the Chief of Ordnance if at any time such ammunition appears to be unfit for storage or issue.

c. The various grades to which lots of caliber .30 and caliber .45, small-arms ammunition are assigned and described in field service bulletins and Army regulations.

103. Packing and marking.—*a.* Small-arms ammunition is packed in wooden boxes, practically all of which have metal liners. Each metal liner is made airtight and tested after it is packed. It should remain airtight unless subjected to rough handling. Most ammunition is packed in boxes which are made in accordance with Ordnance Department drawings. Other types of boxes are in use but will be discontinued when those now on hand have been expended. Cartridges are packed in containers in accordance with the methods described in appropriate technical manuals.

b. The details of marking and painting of small-arms ammunition containers may be obtained from the technical regulations governing small-arms ammunition.

104. Handling and shipping.—*a.* No restrictions other than proper description, packing, and marking are necessary for the shipment of small-arms ammunition. Small-arms ammunition offered for shipment always will be packed in clips and bandoleers, or in pasteboard cartons, before it is placed in wooden or metal containers.

b. No lot of small-arms ammunition will be shipped from an Ordnance storage depot unless it has been examined within 1 year for visible defects and found satisfactory for issue to troops.

105. Storage.—*a.* Small-arms ammunition is not an explosive hazard in storage, although under adverse conditions of storage it may become a fire hazard. With reasonable care in storage, and under the surveillance prescribed in these regulations, small-arms ammunition may be stored safely in any weatherproof magazine or warehouse. In small quantities it may be kept in a barracks storeroom. The conditions most likely to affect small-arms ammunition adversely are dampness, lack of ventilation, and extreme heat such as might be obtained in storing near steam pipes. If the atmosphere is damp or unusual temperatures are experienced, layers of boxes will be separated by dunnage to permit free circulation of air. Ammunition will be piled by lot, and each pile will be placarded to show readily the manufacturer, lot, caliber, and grade of the ammunition in each pile.

b. Small-arms ammunition in containers is piled and arranged in a magazine in accordance with instructions set forth in Army regulations and on Ordnance drawings.

106. Maintenance.—*a.* Maintenance activities in connection with small-arms ammunition include repairs to damaged containers, repacking, resoldering, and air-testing containers. Lots of ammunition which contain an excessive number of visible defects are sorted to reclaim ammunition which is still satisfactory for issue.

b. When damaged containers are repaired, or small-arms ammunition is repacked, the metal liner will be sealed to protect the ammunition from deterioration. The apparatus used for air-testing smokeless powder containers will be used if more suitable equipment is not available. A pressure of approximately 2 pounds per square inch will be used. If the cover of the metal container is damaged, or is difficult to resolder, new covers will be requisitioned from the Chief of Ordnance. Ammunition will be repacked in the same manner as it was originally packed, unless the Chief of Ordnance issues specific instructions to the contrary. The identity of the ammunition will be maintained carefully by lot, and the markings on a repacked container must be a facsimile of those on the original container.

c. The sorting of lots of ammunition which cannot be issued because they contain an excessive number of visible defects, or the reclaiming and repacking of the serviceable ammunition in the lots will not be undertaken except upon specific instructions from the Chief of Ordnance. The process of reclaiming serviceable cartridges includes all of the operations necessary to remove defective cartridges and repack the ammunition for shipment. It involves removal of the ammunition from the old containers, culling out defective rounds, repacking serviceable cartridges into clips, bandoleers, cartons, etc., and resealing the metal container. New cartons, clips, bandoleers, covers for metal lines, etc., required for repacking will be requisitioned from the Chief of Ordnance. However, where practicable, the old containers, etc.,

will be used. When a lot of ammunition is reclaimed it changes its lot number or grade only as specified in Ordnance field service bulletins, except that defective cartridges culled from the lot are automatically classified as grade 3 ammunition.

107. Salvaging.—Salvaging of small-arms ammunition consists of reducing the rounds to their principal components, such as cartridge case, bullet, and propelling charge. The method employed in breaking down the rounds will depend upon the facilities available, and any special instructions issued by the Chief of Ordnance. Since the principal hazard involved is that of fire, care will be taken to guard against an accumulation of powder at the breaking-down operations. Floors and benches will be kept clean, and powder from cartridges will be continuously removed from the immediate vicinity of breaking-down operations so that in case of fire not more than 1 or 2 pounds will be involved, and personnel will not be exposed to unnecessary hazards. Powder obtained from breaking-down operations should be placed in standard containers and stored in the open under tarpaulins or in a shed where a fire cannot cause great damage. Primers in cartridge cases usually are rendered inert by placing the cases in a fire. All salvaged components must be kept separate until disposed of in accordance with Army regulations or directions of the Chief of Ordnance.

108. Fires.—If a fire occurs in small-arms ammunition, the greatest hazard is from flying bullets and cases. However, they are relatively light and usually will not travel more than 200 yards. With ordinary care on the part of the fire-fighting forces, a fire can be quickly controlled without danger.

SECTION XIII

FIXED AND SEMIFIXED AMMUNITION

109. General.—*a.* Fixed ammunition includes all ammunition except small-arms ammunition, which has the cartridge case containing the propelling charge firmly attached to the projectile, so that both are loaded into the gun as one unit. The following are typical examples of fixed ammunition:

Base fuzed shell ammunition, 37-mm. H. E. and practice shell.

A. P. shot, with tracer ammunition, 37-mm. shot.

Point fuzed shell, with tracer ammunition, A. C. and A. A. shell.

Unfuzed shell ammunition, 75-mm. Mk. I H. E. and Mk. II chemical shell.

Shrapnel ammunition, 75-mm. Mk. I and 3-inch A. A. Mk. I.

Point fuzed H. E. shell ammunition, with detonating fuze, 75-mm. M-48 shell.

Point fuzed shell ammunition, with mechanical time fuze, 3-inch A. A. M42 H. E. and practice shell.

Inert loaded (practice) ammunition, 75-mm. sand loaded Mk. I shell and 2.95-inch subcaliber solid shot.

b. Semifixed ammunition is similar to fixed ammunition in that the round is loaded as one unit. However, the cartridge case is not rigidly attached or crimped to the projectile, but it is constructed so that it can be readily removed. These removable cartridge cases are provided whenever the propelling charge is zoned, so that changes can be made in the propelling charge just before the round is loaded into the gun.

c. Semifixed ammunition is stored, handled, and shipped in the same manner as fixed ammunition. Following regulations for fixed ammunition also apply to semifixed ammunition.

110. Light mortar ammunition.—*a.* The types of light mortar ammunition stored at Ordnance establishments are, in general, 81-mm., 60-mm., and 3-inch trench mortar ammunition. The ammunition lot number is marked on the assembly of each type of trench warfare ammunition with the exception of fragmentation, practice, and dummy hand grenades. On these, the lot number is printed on a label on the fiber container. A lot is determined by the uniformity of the materials used in the manufacture of the ammunition; by loading conditions, and other factors which tend to make individual rounds as nearly identical with each other as possible. This matériel should be identified always by the ammunition lot number.

b. Light mortar shell.—The standard ammunition for the 81-mm. mortar, 60-mm. mortar, and 3-inch mortar consists principally of a streamlined projectile fuzed at the nose end, and a fin assembly carrying an ignition cartridge and propellant increments at the base end. There are three types:

(1) *High explosive shell.*—This type is TNT loaded.

(2) *Practice shell.*—Practice shell is loaded with inert material and a practice charge, which is inclosed in a cloth bag.

(3) *Smoke shell.*—The chemical shell (smoke) is described in part IV of this manual with other Chemical Warfare ammunition.

c. There is still for issue a certain quantity of 3-inch Mk. I trench-mortar ammunition of the three types explained above which differs from these in the contour of the projectile, in being assembled with boosters, and in the type of propellant increments used.

111. Packing and marking.—*a.* The methods of packing fixed and semifixed ammunition are as follows:

(1) In wooden boxes with or without metal liners.

(2) In wooden boxes with each round in a fiber container.

(3) (*a*) In packing bundles, consisting of two clover leaf-shaped metal ends, formed to hold three fiber containers, held together with a long carriage bolt.

(*b*) In packing bundles with similar metal ends with an intervening two-faced form to hold six fiber containers.

b. (1) The standard ammunition for light mortars is packed completely assembled in fiber containers; in bundles or boxes similar to the packing of other complete rounds of fixed ammunition. The 3-inch mortar, Mk. I, ammunition is packed in wooden packing boxes, each containing the required number of components for three complete rounds and one additional complete propelling charge. A detailed description of packing and marking will be found in Ordnance drawings, in specifications, and in technical regulations.

(2) Ammunition of the 60-mm. mortar is packed in bundles consisting of three fiber containers, each container holding six rounds; each round in an individual fiber container.

c. Fixed, semifixed, and light mortar ammunition is divided into lots when it is manufactured, and a definite number is assigned to each lot. The location of the ammunition lot number on a round is accurately described in the several technical regulations covering ammunition and is shown on drawings and Standard Nomenclature List. If there is the slightest doubt as to the correct ammunition lot number, report all marks and symbols appearing on the round. The maximum size of a lot of ammunition is fixed by the specifications governing loading and assembling of fixed rounds and is usually 20,000 rounds. However, the actual size of a lot varies and depends upon the stage of manufacture, size of component lots, and other factors.

112. Handling and shipping.—No special precautions other than those set forth in Interstate Commerce Commission regulations and section VI of this manual are prescribed for handling and shipping fixed, semifixed, and light mortar ammunition. It is packed in strong containers, which afford good protection unless the ammunition is subjected to extremely rough handling. Boxes which have been stored for a considerable period of time and which may not be as strong as when manufactured will be reinforced with metal strapping if necessary.

113. Storage.—*a.* Fixed, semifixed, and light mortar ammunition in boxes or packing bundles will be piled or stacked in accordance with Ordnance drawings. Good ventilation to all parts of the pile should be provided.

b. This ammunition always will be stored in wooden boxes or in packing bundles, preferably of the same type in which it was packed originally. Loose rounds of ammunition, or single-fiber containers with rounds therein, will be packed in boxes or bundles before being stored. Incomplete boxes of ammunition will be marked carefully so that they may be identified readily. They will be stored with the lot to which they belong and should be placed on top of the piles. All boxes containing fixed ammunition will be closed effectively, preferably in the same manner in which they were packed originally. No open boxes will be permitted in a magazine.

c. To prevent the possible loss of an entire stock of one kind of fixed ammunition it should be distributed where possible in two or more magazines. For example, if the stocks consist of enough 60-mm. light mortar ammunition and 75-mm. shell to fill two magazines, the two kinds will be divided so that some of each will be stored in each magazine.

d. When loaded components of fixed ammunition are stored separately, they will be stored in accordance with instructions set forth in this manual for storing fuzes, primers, adapters, and boosters, etc. The projectiles will be stored in the same manner as described in secion XIV for separate loading shell.

114. Maintenance.—Maintenance of ammunition includes the removal of rust, repainting, repairing packing boxes, and repacking the ammunition whenever necessary. Work such as that outlined above will not be done in a magazine with other explosives or ammunition, but will be conducted in a nearby empty magazine, repacking house, or room, or in suitable weather in the open at sufficient distance to comply with intraplant quantity distance requirements, but in no case closer than 100 feet from any building containing explosives. The contents of damaged containers will be transferred to serviceable containers. If metal containers are used, they will be air-tested for tightness when packed. The apparatus used for testing cartridge-storage cases can be utilized for this purpose. Containers which are opened for sampling or inspection will be resoldered; or if facilities are not available for doing this work, they will be sealed with tape. When ammunition or containers are repainted, care will be taken to reproduce completely all markings.

115. Renovation and salvage.—*a.* Fixed ammunition which has deteriorated to such an extent that it is necessary to replace the fuzes, boosters, shell charges, or propelling charges, will be renovated or salvaged in accordance with specific instructions furnished by the Chief of Ordnance. Some special facilities are necessary so that the work may be done with the minimum risk or hazard, and so that serviceable components will not be damaged. Bombproofs or barricades used at operations for removing boosters, melting units for removing the shell filler, sand blasting and painting equipment are some of the facilities required. Adequate safeguards against fire and accident always will be provided, and the work will be done in an area isolated from magazines. Intraplant quantity-distance tables will be strictly observed.

b. When fixed ammunition is salvaged or renovated at ordnance establishments under Government contracts the contractor will secure the approval of the commanding officer of the ordnance establishment concerned for the equipment, methods, safety precautions, and amount of explosives or ammunition in process which he proposes to employ. The area in which the work is to be done will be selected by the commanding officer. When work is started the commanding officer will make frequent inspections of the work in progress and will take such steps as are necessary to correct dangerous conditions, enforce safety rules, and safeguard his establishment. Applicable requirements for the manufacture of military explosives and ammunition contained in part III will be complied with.

116. **Fires.**—*a.* Fires in fixed ammunition are not likely to occur unless deterioration has proceeded to such a stage that spontaneous ignition takes place, or burning embers or heated shell are projected into the magazine from an adjacent fire. If a fire does occur in a magazine in which fixed ammunition is stored, every effort will be made to fight the fire, and the magazine will not be abandoned until its is evident that the fire cannot be controlled.

b. A test was made at Aberdeen Proving Ground in 1922 which shows the results that may be expected when fixed ammunition burns.

(1) The ammunition used in this test consisted of 512 boxes (4,608 complete rounds) of 75-mm. H. E. shell, Mk. I, packed nine in a box, each round in a fiber container. This material was evidently in the same condition as received from overseas, as the shipment consisted of rounds from 31 different ammunition lots. All the shell were loaded with TNT.

(2) The ammunition was stacked 8 boxes high, 8 boxes long, and 8 boxes wide, making a pile about 10 feet high, 25 feet long, and 10 feet wide. The windward end was sprinkled with about 10 gallons of kerosene and a fire was kindled at this end of the pile. The fire spread rapidly over the end, top, and sides of the pile, and after approximately 10 minutes the first explosion occurred. During the next 5 minutes the explosions were all from burning propelling charges. Some projectiles and cartridge cases were thrown high into the air and fell at distances up to 200 yards from the pile. Fifteen minutes after the ignition of the pile the first shell detonation occurred; and from that time detonations became increasingly frequent and heavy. The early detonations caused the ends of the pile to fall over, away from the fire. During the period from 15 minutes to 50 minutes after the ignition of the pile, the number and violence of the detonations gradually increased until conditions resembled heavy and continuous firing with heavy guns. During this period shell and shell fragments, cartridge cases, complete rounds, and burning pieces of boxes were thrown in all directions. In only a few cases did explosions occur when material landed after being

thrown from the pile. The detonations were accompanied by large bursts of flame 40 or 50 feet high, and dense clouds of black smoke. About 50 minutes after the start of the fire it was evident that most of the pile had been consumed, although there was still considerable burning material scattered over the area near the original pile. Explosions were quite frequent for another 20 minutes, after which they gradually decreased in frequency until about 2 hours after the start of the fire. During the next hour there were individual explosions from 10 to 20 minutes apart. After 8 hours from starting the fire there were no more explosions.

(3) Examination of the area near the fire showed very little combustible material remained. Cartridge cases without powder, mostly bulged, crushed, or pierced with fragments were found scattered all over the area within 100 yards from the original pile. Unexploded shell were found over the same area. About 2,500 shell and a few complete rounds were gathered up after the fire. Most of the recovered shell fragments showed evidence of only partial detonations of the bursting charge. The complete rounds recovered were mostly in charred fiber containers and were not mutilated in any way. In many instances the shell or the cartridge case was found still encased in the fiber container; one component evidently having exploded and thrown the remainder of the round away from the fire. There were no large or deep craters, the largest crater being about 5 feet across and about 1 foot deep.

c. It is felt that the results of the above-described test are similar to what may be expected from any fire in boxed shell ammunition. Explosions of propelling charges and detonations of shell may be expected without a general detonation of the pile as a whole, or of any considerable part of the pile. The scattering of components probably would be confined to a comparatively small distance from the burning pile.

117. **Safety precautions.**—Fixed ammunition will be handled with care, and it will never be dropped, rolled, or violently thrown. Boxes of fixed ammunition may be handled with roller conveyors, chutes, or trucks, as long as the above precautions against shocks are observed. Safety shoes are not required in handling fixed ammunition, except when it is being broken down for salvage or renovation.

SECTION XIV

SEPARATE LOADING AMMUNITION

118. General.—*a*. In separate loading ammunition the primer, propelling charge, and fuzed projectile are loaded into the cannon separately, or in two or more operations. Since the components of the round such as the primer, propelling charge, and fuze are usually packed separately, they are described in other sections of this manual. This section deals only with separate loading projectiles, fuzed and unfuzed, however, the regulations of this section also are applicable to loaded projectiles from fixed ammunition.

b. Separate loading projectiles are of various types, such as high-explosive shell, shrapnel, and armor-piercing projectiles; and may be either base or point fuzed.

c. Due to the larger caliber, lots of separate loading projectiles are much smaller in size than lots of fixed ammunition. They vary from a few hundred rounds to 20,000 rounds. A lot of 16-inch armor-piercing projectiles usually consists of approximately 500 projectiles, while a lot of 155-mm. shell may contain 5,000 to 20,000 projectiles. Each projectile in a lot is marked with an ammunition lot number, which is the identifying number that will be reported when deterioration, defects, or malfunctions are noted. Each lot of separate loading projectiles has certain characteristics which make it necessary to maintain carefully the identity of all shell in the lot.

119. Packing and marking.—*a*. Prior to the World War the general practice was to crate or box all separate loading projectiles. The same practice was continued during the early part of the war, but later it was determined that crating material was undesirable near the front, and that most types of projectiles could be satisfactorily transported by simply protecting the rotating bands with rope grommets. This method was followed with separate loading high-explosive shell of the types used during the war. Later the procedure was extended to chemical shell of similar calibers. The method of shipping in uncrated condition has from time to time been extended to include certain other types and calibers, such as some sea coast cast-iron target projectiles.

b. The methods of shipment for each type of projectile are shown in the several Standard Nomenclature Lists covering ammunition. Shipment of such new types of projectiles as may be adopted from time to time will be made, in general, in accordance with the following basic rules:

(1) Point fuzed shell with false ogives will be crated.

(2) Point fuzed shell without false ogives will have grommets and eyebolt lifting plugs.

(3) Base fuzed shell with relatively fragile parts such as false ogives, steel caps, and windshields will be crated.

(4) Base fuzed shell without false ogives will not be crated but will have grommets to protect rotating bands.

(5) Dummy projectiles, being easily damaged, will be crated.

(6) Cast-iron projectiles will be fitted with grommets only.

(7) Shell with point-detonating fuzes assembled thereto will be boxed.

c. All separate loading shell are painted a distinctive color to indicate the type of bursting charge. For example, shell loaded with high explosives, such as TNT, amatol, or explosive D, are painted yellow, while black powder loaded shell are painted red. Practice ammunition is painted blue. The caliber and type of cannon for which the shell is intended, the kind of filler, mark number of the shell, and ammunition lot number, are stenciled on each projectile. The several technical regulations covering ammunition, and ordnance drawings and specifications should be consulted for exact details of marking.

120. Handling and shipping.—Separate loading projectiles will be handled with care. The fuze hole always will be closed with a suitable plug which protects the threads, keeps dirt out of the fuze cavity, and affords the best possible protection against fire. The rotating band will be protected carefully against damage, such as dents or cuts that may render the projectile unserviceable. Fuzed projectiles will be rolled slowly and with care so that there is no tendency to arm the fuze. Large caliber projectiles standing on their bases will be lowered with care when it is desired to place them on their sides for handling or storage. Many caps on armor-piercing projectiles have been loosened by failure to observe these precautions. Every effort will be made to avoid injury to or removal of paint from the bourrelet. Exuding shell will not be shipped unless all traces of exudate have been removed from the exterior. The methods of packing of projectiles in freight cars is prescribed in technical manuals and on ordnance drawings.

121. **Storage.**—*a.* In storing separate loading shell the following instructions will be strictly observed, except for igloo magazines which will be stored solid in accordance with current drawings.

(1) Separate loading shell will be stored in fireproof magazines or in magazines which are constructed with the minimum amount of combustible material.

(2) The amount of combustible dunnage in magazines will be reduced to the absolute minimum, and each unfuzed shell will be fitted with a steel or iron fuze-hole plug.

(3) Shell up to and including 10 inches in caliber will be piled in accordance with ordnance drawings; and the distances between piles specified on this drawing will be maintained strictly when the shell are loaded with TNT or amatol. The requirements of paragraph 39 will be observed. Shell loaded with explosive D will be piled in the manner shown on the above-mentioned drawing; but the distance between piles need not be more than the distance required for making examinations of fuze cavities.

(4) Shell larger than 10 inches in caliber will be stored on their bases with appropriate dunnage between the base and floor to protect them from moisture and dampness. Shell loaded with explosive D may be stored in intimate contact; but shell loaded with TNT will be separated from each other by a space equal to the caliber of the shell, for example, 12-inch shell loaded with TNT will be separated from each other by a distance of 12 inches.

(5) When the number of shell to be stored in a magazine is less than the quantity shown on ordnance drawings the reduction of the number of shell in a pile rather than an increase in the distances between piles will be the first consideration.

(6) When shell which require spacing in piles to limit losses from mass detonations are stored without spacing, the requirements of paragraph 39 will be carefully observed.

b. The above requirements are based on the results of a comprehensive series of tests made at the Aberdeen Proving Ground with separate loading shell, in which the following information was gained:

(1) An explosion of shell loaded with TNT or amatol could be confined to one pile if ample distances were maintained between the piles in the magazine.

(2) Distances between piles at which an explosion would be transmitted increased with the number of shell in the pile in which the explosion originated.

(3) All shell in the pile in which the explosion starts will explode. Piles should be reduced to the smallest practicable size if the effects of the explosion are to be limited.

(4) Distances to be maintained between piles to prevent an explosion from being transmitted to adjacent piles must be greater for shell fitted with die-cast white metal fuze-hole plugs than for shell fitted with steel or iron fuze-hole plugs.

(5) It is practically impossible to explode a pile of shell loaded with explosive D. Explosions are usually of a very low order and limited to one shell.

(6) Shell should be arranged in single piles with the noses of the shell in one pile pointing toward the noses of the shell in the next pile, or with the bases of the shell in one pile pointing toward the bases of the shell in the next pile.

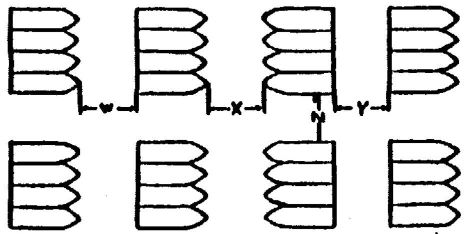
(7) The lateral distance at which explosions were transmitted was several times greater than the nose-to-nose or base-to-base distance.

(8) In connection with the above, it should be noted that if piles are knocked down or disarranged by the explosion of one pile, or of an enemy bomb, or any similar occurrence, it is possible that a subsequent explosion will cause a mass detonation of the disarranged piles.

c. Following is a brief description of the tests which were made:

(1) The shell were arranged in piles, one of which was known as the initiating pile. The purpose was to determine the nose-to-nose, nose-to-base, base-to-nose, and the lateral distances at

which detonations would occur or fail in piles adjacent to the one in which the detonation started. The piles were arranged as shown in the following diagram:



(2) The tests were made principally with 8-inch high-explosive shell, fitted with adapters, boosters, and steel nose-plugs (type A lifting plug). Tests were made also with 155-mm. high-explosive shell fitted with both steel and white-metal plugs. The 8-inch shell were chosen for these experiments after preliminary tests made with shell of several different types and calibers had shown the 8-inch shell to be as sensitive to detonation from an explosive wave or fragments as other types.

(3) The tests were very comprehensive, as they included many different arrangements of the piles, tests to prove the effectiveness of barricades between piles, and tests of shell loaded with explosive D, TNT, and amatol. The number of shell used in the various piles varied from 18 to 600, and series of tests were made in which the initiating pile contained 18, 48, 96, 192, 300, 384, and 600, 8-inch shell, and 160 and 320, 155-mm. shell. The greatest number of shell in any one test (initiating and adjacent piles) was 1,296. The tests were made under conditions which are practically duplicated in magazines.

d. Small-arms ammunition and fixed ammunition in boxes have sometimes been used as barricades between piles of separate loading projectiles. This practice is no longer permitted because of the fire hazards it introduces into magazines filled with separate loading shell. The use of metal dunnage, such as channel iron, is recommended wherever practicable, because it reduces the amount of combustible material in the magazine, and also electrically grounds the pile of shell.

122. Maintenance.—*a.* In removing rust and repainting projectiles, particular attention will be paid to removing rust from

the bourrelet and fuze cavity, and to greasing threads in the fuze hole. The marking and stenciling of repainted projectiles will be conducted with care, so that the marking on the repainted projectile will be a facsimile of the original. The replacement of markings is most important.

b. Oily liquids which exude from shell and sometimes form pools of exudate on the floor will be removed, and affected shell will be tagged or distinctively marked so that they will not be issued for service use. A strict compliance with this requirement is essential, as the exudate is inflammable and small particles of explosive also may lodge in threads in the nose of the projectile. More complete information on the probable cause of exudation and its effects will be furnished by the Chief of Ordnance if desired.

c. Separate loading shell will not have rust removed or be repainted or reworked in a magazine in which explosives or ammunition are stored. Work of this nature will be done in a nearby empty magazine, in a repacking house, or during clear weather in the open at sufficient distance to comply with intraplant quantity-distance requirements.

123. Renovation and salvage.—Separate loading shell which have deteriorated to such an extent that it is necessary to replace the boosters or bursting charges, or to remove the boosters and unload the shell for inert storage, will be renovated or salvaged in accordance with special instructions furnished by the Chief of Ordnance.

124. Fires.—*a.* When the amount of combustible material is limited to the absolute minimum, there is little chance of a hot fire developing in a magazine where only separate loading shell are stored. Every effort should, therefore, be made to control any small fire which starts in a magazine containing separate loading shell; and the magazine should not be abandoned until it is evident that the fire cannot be controlled.

b. In a fire involving separate loading shell, except those loaded with explosive D, stored in combustible buildings the piles will probably explode, a pile at a time. However, a period of 8 or 10 minutes will usually elapse before the fire becomes hot enough to cause the first detonation.

c. The possibility of a heated shell being projected into a magazine, and then exploding, is extremely remote, however, if this should occur, the explosions probably would be limited to one pile, if the shell are stored in accordance with the requirements for spacing.

125. Safety precautions.—The special safety precautions to be observed in handling and storing separate loading shell are as follows:

a. Fuze-holes always will be closed with a suitable plug.

b. Shell will be protected from fire and heat.

c. Shell will be handled carefully. They will not be violently rolled, or subjected to any kind of rough handling. If fuzed projectiles are rolled, they will be rolled slowly to prevent the arming of the fuze.

Section XV

BOMBS

126. General.—*a.* Aircraft bombs are of the following types: practice, fragmentation, demolition, chemical, armor piercing, and incendiary. A detailed description will be found in appropriate technical manuals, and on ordnance drawings and specifications. Chemical bombs are discussed in part IV of this manual. Following is a brief description of other types:

(1) Practice bombs, as the name implies, are used for bombing practice and for the instruction of personnel. Usually they have the same characteristics of form, weight, method of handling, flight, and accuracy, as corresponding service bombs. Usually they contain sand and a reduced bursting charge of explosive. Usually they are stored and issued in the form of components, as follows:

Empty bomb bodies.

Fin assemblies and fin-securing components.

Spotting charge, either as a cartridge, a bag of black powder, or a unit assembly consisting of a metal container, powder charge, and fuze.

Adapter and booster, loaded or empty, as required.

Fuzing components, where necessary.

The sand filler for the bombs is added in the field.

(2) Fragmentation bombs are intended for use against personnel. They are comparatively small in size and designed to give maximum fragmentation effect.

(3) Demolition bombs are intended for use against enemy works and ships. They depend upon a blast effect for the destruction of such structures. They have larger bursting charges than artillery shell of corresponding weights varying from 100 pounds to 2,000 pounds, or larger.

b. Bombs are divided into lots varying in size from several thousand for the smaller types to a few hundred for large bombs. Each is marked with an ammunition lot number which is used to identify the lot when reporting evidences of deterioration or malfunctioning.

127. Packing and marking.—*a.* The present prescribed methods of packing bombs for shipment are as follows:

(1) Fragmentation and chemical bombs are packed in metal tubes assembled in bundles (20 lb., M41), wooden boxes (25 lb., M3), or metal crates containing from two to five bombs each (30 lb., M5). Usually, fuzing components are packed in the same container.

(2) One hundred pound demolition bombs are packed in metal crates, one in a crate, or are packed as described in (3) below. The fuzes, primer detonators, arming wire, swivel loop, and one fin brace for the 100-pound Mk. IMI bomb will be inserted in a component metal box which will be assembled to the metal crate.

(3) All demolition bombs except the 100-pound bomb are shipped without fins with metal shipping bands to protect the suspension lugs, and to facilitate handling. Fin assemblies are shipped separate from the bomb in wire-bound, veneer wood, packing boxes. When shipments are made to using services fuzing components are packed in a wire-bound accessory box which is inclosed in the fin assembly box. In interdepot shipments, fuzing components are shipped in their respective boxes.

b. A detailed description of the packing boxes and crates, including details as to size and contents, will be found in technical regulations and on ordnance drawings and specifications. Spotting charges for practice bombs normally consist of a few pounds of black powder. These charges are stored, handled, and shipped under the regulations for black powder as contained in section VIII, with the exception that M1A1 spotting charges are not removed from their boxes but are stored as received.

c. Bombs, packing boxes, and crates for bombs are marked to show the size, lot number, filler, and other characteristics; including marking required by Interstate Commerce Commission regulations. The painting and marking of each type of bomb and its packing box or crate are described in applicable technical regulations. Bomb packing boxes which contain fuzes, or primer-detonators may be marked with a stripe of red paint to show the location of the fuze, or primer-detonator.

128. Handling and shipping.—Bombs will be handled with care and protected against shock. Those shipped without boxes or crates will have the fuze-holes in the nose and tail closed with suitable plugs. Projecting lugs will be protected against damage. Bombs will not be shipped with the primer-detonator in place. Fin assemblies shipped separately or attached to bombs will be protected carefully to prevent damage.

129. Storage.—*a.* (1) In storing, a distinction is made between fragmentation and demolition bombs. Fragmentation bombs, when packed in wooden boxes like fixed ammunition are not likely to detonate en masse if a fire occurs in the magazine.

(2) Fragmentation bombs packed in metal crates are susceptible to mass detonation and must be stored in a manner similar to that specified for demolition bombs.

b. Demolition bombs have very thin walls. They are regarded as one of the most hazardous types of ammunition because of their tendency to detonate en masse if a fire occurs or a heated fragment is projected into the magazine in which they are stored. One of the most disastrous explosions on record originated from a fire in a magazine in which was stored a large number of demolition bombs packed in boxes. No feasible way of separating bombs or barricading piles of bombs in a magazine to reduce the hazard of mass detonation has been found. Safety can be obtained only by reducing the possibility of fire to an absolute minimum. Bombs should be stored in fireproof magazines without combustible dunnage.

c. To minimize the fire hazards, demolition bombs which may be packed in wooden boxes or crates will be removed therefrom before storing. Steel dunnage is preferred and will be used unless instructions to the contrary are issued by the Chief of Ordnance.

Fuzes and primer-detonators must not be packed with bombs except in the case of metal-crated 100-pound bombs. Fuzes and primer-detonators may be stored with 100-pound bombs in igloo magazines.

d. Demolition bombs will be so piled that fuse cavities can be readily inspected and visible signs of exudation detected. Bombs with fin assemblies attached will be piled carefully to avoid damage to fin assemblies.

e. Bombs will be stored in those magazines which offer the best protection against fire and missiles. Approved, arch-type, earth-covered, concrete igloo magazines will be used if available.

f. Bombs in storage will not be fused or fitted with primer-detonators.

130. Maintenance.—Maintenance activities include removal of rust, repainting, remarking, removal of exudate from the bombs and floors of the magazine, and repairs to containers. The removal of rust and repainting will not be done in a magazine in which explosives or ammunition are stored; but these operations may be conducted in an empty magazine, or in suitable weather in the open at sufficient distances to comply with intraplant quantity-distance requirements, but in no case closer than 100 feet from any building containing explosives. Exudate is a dangerous fire hazard and will be cleaned from bombs and floors of magazines. When bombs are repainted the painting and marking must be a facsimile of the original painting and marking.

131. Renovation and salvage.—Bombs will not be renovated, salvaged, or modified except with the specific approval of the Chief of Ordnance, who issues the necessary instructions for the performance of such work.

132. Fires.—If a fire occurs in a magazine in which fragmentation bombs are stored in boxes, it is probable that the bombs will detonate intermittently like fixed ammunition. If a fire occurs in a magazine in which demolition bombs or fragmentation bombs in metal crates are stored, it is almost certain that a mass detonation of the bombs will occur. Safety from mass detonation of bombs lies only in preventing fires and by reducing dunnage and other combustible material in the magazine to the absolute minimum.

SECTION XVI

FUZES, PRIMERS, BOOSTERS, AND DETONATORS

133. General.—*a.* Fuzes, primers, boosters, primer-detonators, and similar loaded components form a distinct class of ammunition when they are not assembled to or packed with projectiles or bombs.

b. Loaded components are divided into lots, and always will be identified by lot number. The size of a lot usually varies from 5,000 to 25,000 components and is dependent upon the stage of manufacture and other factors. Each lot is made and tested under uniform conditions and has certain characteristics which require that the identity of all components in the lot be carefully maintained. Where practicable, the lot number is stamped on the components, but it always appears on the containers in which they are packed.

134. Packing and marking.—*a.* The practice with respect to packing of those loaded components which are packed separately from the ammunition or bombs with which they are to be used, differs from one component to another, depending upon the character of the component. Provision is made for the packing of every item of issue to the field, and for the interplant shipment of all loaded components. In some cases in the past artillery fuzes have been shipped in wooden boxes provided with hermitically sealed metal liners, and trays for supporting the fuzes. In other cases, fuzes were shipped in individual metal containers. These practices will be continued, except that fiber instead of individual metal containers will be used. Bomb fuzes which contain no explosives were packed in wooden boxes without metal liners, with the fuzes supported in trays to avoid their striking together. Bomb fuzes of more modern design, containing explosive components, will be shipped in individual containers within wooden boxes. Primers intended for assembly

into complete rounds of ammunition are packed in paper cartons, waterproofed by dipping in parraffin, within hermetically sealed metal liners, in wooden boxes. Primers for separate loading ammunition—that is, for issue to the field as primers—are packed in small metal boxes within wooden boxes. Adapter-boosters for bombs and adapters and boosters for artillery ammunition are packed in trays within unlined woden boxes for shipment to loading plants. For detailed information regarding the method of packing each type of component reference should be made to the proper drawing.

135. Handling and shipping.—*a.* Loaded components offered for shipment will be supported or so packed in containers that they will not strike against each other. If the containers in which the components were originally packed are not available, boxes and trays which will insure protection against shocks and rough handling will be constructed. All loaded components, even when properly packed, will be handled with care. They will not be thrown or dropped on the floor or on other containers.

b. The painting and marking of components and their containers are shown on ordnance drawings and specifications.

136. Storage.—*a.* Components will be stored with the tops of the boxes up. Storing of all of one type in a magazine should be avoided, if possible, because a fire or an explosion may result in the loss of the entire quantity. In no case will more than 50,000 fuzes of any one model nor more than 150,000 of all models be stored in a single magazine. This prohibition does not apply to grenade fuzes, which are included in class 8 of military explosives and ammunition, with primers, detonators and like components. All boxes and containers opened for inspection will be resealed. They will be piled in accordance with ordnance drawings. Incomplete boxes will be marked plainly for identification and placed on top of the piles. Open boxes of loaded components will not be stored in a magazine.

b. The storage of class 6 fuzes will conform with the requirements of paragraph 89.

137. Maintenance.—Maintenance includes repairs to containers, sealing, and air testing of containers which have been opened for inspection. Containers opened for inspection will be resoldered or effectively resealed with adhesive tape. No work, such as removing rust or repainting will be done except by specific direction of the Chief of Ordnance, who will furnish the necessary instructions. Containers will not be opened or repaired in a magazine containing explosives or ammunition. This work will be done in a near-by empty magazine, in a repacking room, or during clear weather in the open at sufficient distance to comply with intraplant quantity-distance requirements, but in no case closer than 100 feet from any building containing explosives.

138. Renovation and salvage.—Loaded components will be renovated, salvaged, or modified only in accordance with specific instructions furnished by the Chief of Ordnance.

139. Descriptions of components.—Descriptions of components such as fuzes, boosters, and primers will be found in appropriate technical publications.

140. Fires.—*a.* Tests made at Aberdeen Proving Ground with piles of fuzes in boxes similar to magazine piles showed that in case of fire fuzes will detonate a box at a time. Missiles are light and have a very limited range, usually not over 200 yards. An attempt should be made to put out a fire which occurs in a magazine in which fuzes are stored. If the fire cannot be controlled, the magazine should be abandoned and the efforts of the fire-fighting forces confined to protecting adjacent magazines. Personnel fighting the fires should seek such cover as is available, or protect themselves against missiles by lying flat on the ground.

b. When primers in sealed containers and wooden boxes are subjected to fire they usually explode a box at a time. There are no records in the Ordnance Department which indicate that a mass explosion is to be expected when primers are packed in this manner. Every effort should be made to control a fire which involves primers. The above, however, does not apply to primers which have been removed from their containers and are in intimate contact with each other. Under such conditions it is known definitely that mass explosions occur in cases of fire.

c. When packed in boxes, most of the smaller types of adapters and boosters, such as the Mk. III and Mk. III–A, explode a box at a time. Some of the larger types of boosters, however, such as the Mk. II, Mk. IV–B, Mk. VI–B, and bomb boosters, may detonate in quantities of several boxes at one time. Usually the missiles formed are light, have a limited range, and the fire usually can be controlled and prevented from spreading to adjacent magazines.

141. Safety precautions.—Fuzes, primers, boosters, and primer-detonators are loaded with explosives which are sensitive to shock and friction. Components of these types are supported in trays or racks, to protect them against shock, but they must be handled with care at all times. The covers of wooden boxes for these components are fastened with screws. Nails will not be used.

Section XVII

PYROTECHNICS

142. General.—*a.* Pyrotechnics for military use are divided into two general classes: Illuminating and signaling. These two classes are further subdivided into pyrotechnics for ground troops and aviation pyrotechnics. Pyrotechnics are described in technical regulations, on ordnance drawings, and in specifications.

b. Pyrotechnics are divided into lots which represent a definite quantity that has been manufactured and tested under uniform conditions. The lot number usually appears on the individual pyrotechnics and on the containers.

143. Packing and marking.—Pyrotechnics are packed in metal-lined or unlined, nailed or wire-bound wooden boxes. Those in unlined boxes are packed in inner containers consisting of sealed corrugated board cartons, cylindrical fiber containers, or metal containers. The cartons are dipped in paraffin to protect the contents from moisture. The M8A1 aircraft flare is packed in an individual fiber container which in turn is inclosed in a single-flare, wire-bound box. The methods of packing pyrotechnics made during 1917–1918 are described in O. O. Form 2027, Military Pyrotechnics; for pyrotechnics manufactured since the war, in technical regulations, on ordnance drawings and in specifications. Pyrotechnics and their containers are labeled or marked to comply with Interstate Commerce Commission regulations and Army specifications and drawings. This marking includes the type or kind, date packed, lot number, and quantity. The M8A1 flares, their containers, and their packing boxes, are marked to indicate the date before which they must be expended.

144. Handling and shipping.—Military pyrotechnics are shipped in accordance with Interstate Commerce Commission regulations for fireworks. They will be handled with care. Containers will not be subjected to rough handling which may damage the contents.

145. Storage.—Pyrotechnics will be stored in containers as indicated in current ordnance drawings. Some pyrotechnics deteriorate rapidly in the presence of moisture and high temperature and may become unsafe. Good protection against moisture or dampness and high temperature should be provided. Containers which show signs of dampness or moisture will be carefully examined; and if the pyrotechnics have been damaged, they will be destroyed.

146. Maintenance.—Only pyrotechnics in metal cases, such as aviation cartridges and airplane flares, are reconditioned or renovated. Such work will be done in accordance with specific instructions of the Chief of Ordnance.

147. Fires.—Some pyrotechnics may ignite spontaneously if subjected to adverse conditions such as moisture and high temperatures; but, under these conditions, most types tend to become less sensitive and more difficult to ignite and burn. These remarks apply mainly to pyrotechnics manufactured during the World War. Pyrotechnics manufactured since that time are well protected against deterioration in storage. A very hot fire is created by burning pyrotechnics as practically all types contain some oxygen-bearing constituents. Water should not be used on burning pyrotechnics containing magnesium. Pyrotechnics such as airplane flares may explode, but most other types burn with an intense heat and without serious explosions.

148. Safety precautions.—Pyrotechnics should be protected against moisture, should be handled with care, and protected against shocks. The boxes should not be dropped or thrown. If pyrotechnics are exposed to moisture, they should be segregated from all other materials until an examination has been made to make sure that they are serviceable and are not dangerous.

Section XVIII

MISCELLANEOUS AMMUNITION AND EXPLOSIVES

149. General.—There are a number of types of ammunition and explosives which have not been discussed previously. In this section they are described briefly with reference to storage, maintenance, and general safety precautions.

150. Blank ammunition for artillery.—*a.* Blank ammunition is completely assembled and packed in boxes in individual fiber containers at arsenals or depots, and shipped to the various stations. This ammunition will be treated in the same manner as described for fixed and semifixed ammunition in section XIII of this manual.

b. The weight of the charge and the model of gun for which the ammunition is intended are marked on the cartridge case, the fiber container, and the packing box. Additional markings, including those required by Interstate Commerce Commission regulations, are stenciled on the box.

c. Blank ammunition will be loaded only at designated ordnance establishments.

151. Smoke-puff charges.—The only items of the smoke-puff outfit that are of interest from an ammunition and explosive standpoint are the black powder charges and percussion caps. The black powder charges are packed in small cartons and wooden boxes. They will be handled in the manner prescribed for black powder, and the regulations of section VIII will govern their storage, handling, and shipment. The percussion caps are packed in containers and wooden boxes, and will be stored in accordance with the provisions of Section XVI, Fuzes, Primers, Boosters, and Detonators.

152. Demolition material.—*a.* The Ordnance Department stores for the Engineer Corps of the Army several kinds of demolition materials, such as explosive blocks, dynamite, blasting caps, and blasting fuse.

b. Explosive blocks are of two types:

(1) Explosive, TNT, rectangular, one-half pound blocks have a cavity into which the detonator or blasting cap is inserted.

(2) Explosive, nitrostarch is packed in half-pound blocks and 1-pound packages which contain four quarter-pound blocks. The quarter-pound and half-pound blocks must not be broken into smaller pieces. Nitrostarch is much more sensitive than TNT and should not be broken or roughly handled. This material should be stored in a cool dry magazine and high temperatures should be avoided.

Explosive TNT rectangular and explosive nitrostarch blocks will be stored in accordance with the provisions of Section IX, High Explosives.

c. Blasting caps tetryl electric and new electric are special blasting caps primarily for use with explosive blocks. Commercial blasting caps are generally designated by numbers. Ensign Bickford safety fuse will be stored in accordance with the provisions of Section XVI, Fuzes, Primers, Boosters, and Detonators. Primacord Bickford fuse is filled with a high explosive, and will be stored in accordance with the provisions of section IX.

d. Dynamite will be stored in accordance with the provisions of section IX. Special attention will be given to oily stains or exudation of nitroglycerin. Stains of this nature on the floor of a magazine will be neutralized by scrubbing the floor thoroughly with a solution of one-half gallon of water, one-half gallon of wood alcohol, and 2 pounds of sodium sulphite or potassium sulphite.

e. "Instantaneous" fuse used by the Engineer Corps is sometimes stored at ordnance establishments. This fuse burns with extreme rapidity. If it is mistaken for safety fuse, serious accidents may result. Purchase of this fuse has been discontinued but some of it may still be in stock. It is colored red.

153. Photoflash bombs.—Photoflash bombs are loaded with flashlight powder, which is similar to black powder as to hazards in handling and storage. Careful handling of photoflash bombs is essential to avoid damage to the fiber cases and parachute pull-out cords. Photoflash bombs which have become damaged in handling or storage, or those which fail to function when

dropped should be destroyed in accordance with the regulations of paragraph 66e for artillery shell. The safety precautions which are attached to the outside of each bomb-case will be observed carefully.

154. Antitank mines and fuzes.—Antitank mines and fuzes are packed together in boxes containing five mines and five fuzes to the box. The mines and fuzes in plywood fuze containers are placed with diameters upright in compartments within the box. High explosive mines for service use are loaded with TNT or with trimonite, and employ a detonating fuze containing tetryl. The regulations of section XV will govern the storage, handling, and shipment of these mines and fuzes.

The practice mine consists of an unloaded mine body. The practice mine fuze is loaded with 100 grains of red phosphorus and 60 grains of black powder, A-No. 4. The regulations of this section covering blank ammunition will govern the storage, handling, and shipment of practice mines and fuzes.

155. Grenades.—*a.* Grenades are of two types: Hand and rifle. Hand grenades are classified as fragmentation, practice, and chemical. The only standard rifle grenade is loaded with the chemical filler, CN.

b. Practice grenades are empty grenade bodies provided either with grenade fuzes with detonators, or with black powder bursting charges and grenade fuzes having black powder igniting charges.

c. Training grenades do not contain explosives, and are classified as inert metal components.

d. Grenades are packed as follows: The standard method of packing hand grenades is in individual fiber containers in boxes. However, there are still some chemical and fragmentation hand grenades packed in metal lined boxes, and some fragmentation and training hand grenades with and without fuzes in wooden packing boxes. Rifle grenades are packed fuzed, in wooden packing boxes with the cartridges and rods in separate boxes. The packing and marking of grenades are covered in technical regulations, on ordnance drawings, in specifications, and in standard nomenclature lists.

SECTION XIX

METAL COMPONENTS

156. General.—*a.* Metal components, loaded and unloaded, are an important part of the reserve ammunition maintained for use in an emergency. They always will be protected against rust, deterioration, or damage, so that when shipped to a loading plant only such simple operations as cleaning and repainting will be required to prepare them for loading and assembly.

b. Metal components are divided into lots. The size of a lot varies for various types of components, the stage of manufacture, and other similar factors. The first lots manufactured are usually small containing from 1,000 to 5,000 units. As manufacturing methods become well established the lots may increase in size to 25,000 or 50,000 units. Lots of small components such as primers, boosters, and fuzes are much larger than lots of projectiles and bombs. Metal components are manufactured to meet definite physical and chemical requirements of War Department specifications and drawings, and each lot is accepted for use on the basis of specific tests and inspections.

157. Packing and marking.—*a.* Considerable variation exists in the methods used for packing metal components. Under normal conditions they usually are shipped directly from a manufacturing plant to a loading plant in carload lots. To avoid unnecessary expense it is the general policy to pack components in boxes or crates which can be reused for shipment of the same components after they are loaded. For example, many of the inert fuzes now in storage are packed in the standard boxes for loaded fuzes, the only difference being that the metal liners are not sealed. The above policy cannot be applied to components for rounds of fixed ammunition. Cartridge cases, shell and shrapnel, are packed in commercial wooden or fiber boxes of a convenient size and weight.

b. Although variations exist in methods of packing, it will be noted in all cases that the main objective is to make certain that the method used will protect the components against damage during shipment, and afford reasonable protection against deterioration in storage.

c. All metal components are identified by mark or model numbers, lot numbers, manufacturer's initials, and inspector's initials. Wherever possible this information is stamped directly on the components, and always on the containers in which components are packed. The place where the marking will be found is shown on the ordnance drawing for each component. For example, the lot number, manufacturer's initials and inspector's initials are stamped into the steel body of a shell just forward of the rotating band. In most cases this stamping is not visible until the paint or protective coating is removed.

158. Handling and shipping.—Where practicable, metal components will be shipped in accordance with the methods specified for loaded components. Empty shell should be shipped in accordance with the specifications for packing projectiles in freight cars. Components always must be handled and shipped so that they will reach their destination in good condition.

159. Storage.—*a.* Metal components which comprise part of the reserve, and which may remain in storage for a number of years, will be protected carefully against deterioration. When necessary, they will be reconditioned or renovated in accordance with specific directions of the Chief of Ordnance.

b. They will be stored in buildings which afford good protection against the weather—particularly against moisture and dampness. Temporary buildings with steel or corrugated iron roofs, and buildings with dirt floors, are not suitable for storage of metal components. Magazines or warehouses with concrete floors should be used. The roofs of buildings in which metal components are stored should be inspected frequently, for if a leak occurs the material which becomes wet usually will require reconditioning or renovation. Corrugated-iron roofs are subject to sweating and extensive damage may result from this cause.

c. Metal components in boxes will be piled in accordance with storage practice prescribed in Army Regulations, and such additional instructions as may be prescribed by the Chief of Ordnance. Precautions will be taken to insure that the components at the base of piles are not damaged, and that the weight of upper tiers will not crush boxes in lower tiers, allowing the pile to topple over. For example, cartridge cases for 75-mm. ammunition are stored in fiber containers. If the containers are stored so that cartridge cases are standing squarely on their bases they will support several upper tiers without damage, but if they are stored on their sides the containers may collapse, damaging the cartridge cases. Cartridge cases not packed in containers should be stored on their bases and not on their sides. Boards should be placed between each tier to distribute the weight and insure a stable pile. In storing empty shell, precautions will be taken to protect the rotating bands. When dunnage is not used, shell will be staggered in piles, so that no weight rests on the bands. A solid foundation is of primary importance, because if foundations give way and the piles topple over, shell may be badly damaged. In piling and stacking metal components the allowable floor load should be determined and checked against the weight of the components in a pile. The allowable floor load will not be exceeded.

160. Maintenance.—Metal components which are deteriorating will be reconditioned or renovated in accordance with specific instructions furnished by the Chief of Ordnance.

PART III

SPECIAL SAFETY REGULATIONS FOR THE MANUFACTURE AND LOADING OF MILITARY EXPLOSIVES AND AMMUNITION

SECTION XX

SAFETY OPERATING REGULATIONS FOR MANUFACTURING AND LOADING PLANTS

161. General.—*a.* In addition to the safety regulations contained in parts I, II, and IV of this manual, which also must be observed when applicable, the following rules and regulations will govern operations in buildings, rooms, or portions of a plant in which hazardous materials are manufactured, loaded, or handled.

b. The rules as formulated herein offer the minimum requirements compatible with proper safety. It is not intended to limit the establishments in this direction, and it should be expressly understood that commanding officers are entirely free to superimpose any additional safety rules which may be desirable because of local conditions which necessarily cannot be covered by a manual of this general nature.

162. Safety organization.—*a.* The safety organization of a manufacturing or loading plant necessarily should be more extensive than that of a storage establishment. A satisfactory organization for large plants should consist of: (1) A safety officer, (2) a safety board, (3) all foremen, (4) a safety engineer where necessary.

b. The safety board should consist of three or more members appointed by the commanding officer.

c. The duties of a safety board are to advise the commanding officer relative to the establishment of safety measures necessary for the proper safeguarding of personnel and property. In addition to its other duties, this board should recommend the maximum amount of hazardous material, and the maximum number of persons to be permitted in each operating room of the plant. Recommendations and decisions of the safety board will be executed as directed by the commanding officer.

d. All foremen are responsible under the direction of the commanding officer for the enforcement of safety rules and standards for all work performed under their supervision.

163. Duties of a resident safety engineer.—*a.* The resident safety engineer, under such rules and regulations as may be prescribed by the commanding officer, and the safety officer, should ordinarily be held responsible for coordinating safety practices at the establishment with comparable and applicable safety practices followed by similar commercial industries. He should act in the capacity of professional adviser to the commanding officer in all questions relating to the safety of the establishment. He may perform such additional administrative duties as may be assigned to him by proper authority.

164. Hazardous operations.—*a.* All process equipment must be examined by a competent person specifically designated for the purpose, to insure that it is in proper and safe working condition before work is commenced.

b. If machinery or other equipment is out of order or gives indications of improper operation or serious defect, or if foreign substances or objects are discovered in hazardous materials, work must be stopped at once, unless the dangerous condition is cor- other than operations incident to storage, will be permitted in any storage building.

c. No operations in which hazardous materials are involved, other than operations incident to storage, will be permitted in any storage building.

d. Hazardous materials in loose or liquid form must be transported in covered containers. No liquid explosives will be carried outside a building by hand in buckets, unless special permission is obtained from proper authority.

e. Explosives dust or other hazardous materials will not be allowed to accumulate on radiators, heating coils, or steam or hot-water pipes.

f. Efficient drowning tanks and arrangements for rapid drowning must be provided for all hazardous materials in an acid state, or which are likely to decompose.

g. No experiments, tests, other than routine work, will be undertaken in an operating building without first notifying the person in charge. If such work adds to the general hazard and can be performed otherwise, it must not be done during operations or with unnecessary persons present.

h. Major repairs or changes will not be undertaken in an operating building during regular operations, nor without the removal of the hazardous materials, nor without the knowledge of the employee in immediate charge of the building, nor with unnecessary persons in the immediate vicinity. Loose hazardous materials must be cleaned up and surfaces washed or desensitized as far as practicable. Danger signs will be used when men are working out of the normal line of vision, for instance, overhead.

i. Immediately after any repairs or changes all tools and materials must be removed and accounted for before the building is in proper condition to operate. The person in immediate charge of such work may remain in the building to see that it operates properly, but he first must send his assistants to a safe distance.

j. Waste materials, sweepings, or refuse contaminated with hazardous materials must not be left in or near operating buildings. It should be taken, as soon as practicable, in closed containers to buildings set apart for its recovery, or to the burning ground to be destroyed in small quantities under careful supervision. Such material must not be buried or thrown in any stream, or tidewater unless it is decomposed by, or is soluble in water. The latter disposition will be permitted only if authorized by local ordinances.

k. Paints, oils, etc., unnecessary to operation will not be permitted to remain in operating buildings. Oily waste must be kept in approved waste cans.

l. Condemned equipment which has been used with hazardous materials must not be removed outside the plant until it has been freed from contamination.

m. All operating buildings must be kept clean and orderly, and their immediate surroundings must be maintained clear of rubbish, undergrowth, or other readily combustible matter. All implements must be kept in designated places. Explosive or highly inflammable dust will not be permitted to accumulate.

n. Tools or other implements used in the vicinity of hazardous materials must be handled carefully and kept clean. Metal tools used in any operation will be those approved by competent authority, and the method of their use must be specifically outlined.

o. Containers of hazardous materials, shell, and other heavy objects must be lifted or wheeled, and not dragged, dropped, or thrown about in operating buildings.

p. Before freight cars, trucks, or other conveyances or carriers which have contained hazardous material leave the plant they must be inspected and freed from contamination.

q. Portable extension lights must not be introduced into operating buildings while hazardous materials are present, unless absolutely necessary. Any light introduced must conform with requirements of paragraph 169c.

r. Hand fire equipment may be provided at operating buildings. In case of fire in buildings containing loaded shell or explosives which may detonate or explode upon exposure to intense heat, employees must leave the vicinity after the fire has passed the incipient stage. This provision applies also to hazardous materials in closed vessels or tanks exposed to intense heat.

s. Safety shoes and special clothing will be worn in operating buildings containing hazardous materials, as required by the type of material or nature of the operation.

165. Intraplant transportation.—*a.* Locomotives used in intraplant transportation will be of such a type, or will be so equipped that they cannot set or communicate fire. Inspections will be made frequently to insure their safety.

b. Chemical fire extinguishers must be carried on all locomotives and self-propelled vehicles.

c. The carrying of hazardous material on locomotives, tenders, or electric tractors is prohibited.

d. Locomotives must not remain in front of buildings containing hazardous materials longer than necessary to "spot" cars for loading or unloading purposes, and doors to these buildings must be closed when locomotives which do not comply with the provisions of paragraph 7a (21) are passing.

e. Switching cars by making a "flying switch" is prohibited. All Interstate Commerce Commission safety regulations relating to safety devices, safety guards, etc., should be applied to intraplant transportation.

f. Prominent crossing signs should be displayed on each side of all railroad crossings. Openings between rails must be suitably filled at crossings.

g. Trestles must have a walkway and railing on one side.

h. Standard-gage tracks should have clearances as approved by the American Railway Engineering Association. Particular attention should be given to height and horizontal clearance of loading platforms, horizontal and vertical clearances for buildings and other structures, and horizontal distances between

tracks. The distance from the top of rails to overhead wires carrying under 300 volts should be 25 feet; for wires carrying over 300 volts, 35 feet.

i. Tramcars, trucks, and other conveyances used in the transportation of hazardous materials must be so constructed that no part of the load can fall off.

j. Motortrucks or other carriers with metal strips in the body floor must not be used in the transportation of hazardous materials unless a wooden floor or lattice is provided.

k. Trucks or wagons loaded with hazardous materials must not stop near any point where a fire may be burning, including blacksmith shop, forge, welding plant, burning plant, or locomotive.

l. Trucks used in the transportation of hazardous materials must be kept in good condition, particularly as to brakes, tail gates, doors, exhausts, leaks of fuel, etc. Frequent inspections shall be made of each vehicle so used to insure its safety.

m. Segregation of explosives and loaded components should be in accordance with the storage chart (Appendix II).

n. Explosives or hazardous material, whether in containers, in bulk, or loaded into projectiles, must not be handled roughly, thrown about, tumbled over the floors, or over other containers, dragged or pushed along the floor, or in any way handled so that shock or friction may cause a fire or an explosion.

o. Narrow gage or industrial tracks should have the following clearances: Width not less than 18 inches over the widest car used; headroom not less than 7 feet. Center to center of parallel tracks should equal the width of the widest car, plus 2½ feet.

p. Parking of privately owned automobiles within Ordnance stations will be so controlled as to minimize fire hazards. Automobiles will be parked in designated areas only, outside the plant fence if practicable.

q. Trucks or vehicles loaded with hazardous materials must not be left unguarded.

166. Machinery.—*a.* All protective appliances required by the laws of the State in which the plant is located must be installed, whether or not specifically included in these safety standards.

b. Whenever practicable all protective appliances should be removable and readily replaceable. Such protective appliances must be strong enough to retain their shape when removed.

c. Adequate protective appliances must be used on all installations.

d. Where access to the machinery is necessary while it is in motion, protective appliances or sections of the same may be hinged. Positive locking devices are required, and in case of covers or gates, provision must be made to prevent the devices from being self-closing. No removable or hinged sections are permissible for use in routine oiling while machinery is in motion.

e. Serious accidents have occurred in the handling and use of discarded explosives process machinery, pipe fittings, and equipment, because all waste explosives had not been removed. Before any equipment used in the manufacture or handling of explosives is moved from the area where it has been in use, it must be cleaned and thoroughly inspected. Before selling any scrap metal which has been previously used in the manufacture of explosives, it must be heated in a hot fire at the burning ground at a temperature higher than the decomposition point of the explosive. The heating of such materials is a hazardous operation, and all due precautions must be exercised.

f. All exposed projections attached to revolving shafting must be guarded.

g. Shafting within 7 feet of the floor must be completely guarded. Provision must be made for the safe oiling of all bearings. Overhead chains or belts which because of speed or size would injure operators, on breaking, must be guarded. Every spoke pulley, the bottom of which is 6 feet or less above the floor, or working level, shall be protected by guarding as required for belts.

h. All belt shafting and starting devices should be simple, with locking attachments in the stop position. Shafting and starting or stopping handles must be in a safe location and must not project into the passageway or be otherwise located so that the machine may be accidentally started.

i. Belt shifting by poles should be avoided. Where it is necessary to have pegs for idle belts they must keep the belts away from moving parts, bearings, oil, or grease.

j. All electrical safety control apparatus will comply with the regulations as set forth in paragraph 169c.

k. At all points where equipment is being repaired, oiled, or which for other reasons must not be started because of danger to some employee, a danger sign will be attached to the starting handle of the switch.

l. Chains, hooks, slings, and ropes must be inspected regularly.

m. Emery wheels must have a substantial safety hood and should have large-size flanges with cushioned washers. Speed of emery wheels must not exceed the manufacturer's guarantee. Examination of the wheel for cracks should be made at regular intervals, and the face should be turned up at frequent intervals.

167. Woodworking machinery.—*a.* Woodworking shops, other than small repair shops, should have an efficient exhaust system for wood waste.

b. Planer heads must be substantially covered with a removable guard over the exposed portion of the planer blades.

c. Rotating parts of woodworking machinery should be free from all projections or should have the projections guarded.

d. Circular saws must be completely incased below the table and must have an adjustable hood protecting the operator above the table. Band saws must have both wheels and return side of band incased with a substantial removable housing. The cutting side must be housed with an automatically adjustable guard, giving protection at all openings or capacities.

e. Jointers and surfacing machines must be equipped with safety cutter heads. Power shapers, matching machines, mortising machines, tenoning machines, and similar types of machines must have cutter heads completely hooded or guarded. Sanders must have a revolving head hooded with an automatically adjustable guard.

f. Nailing machines must have safety housing and safety stop devices.

SECTION XXI

SAFETY STANDARDS FOR MANUFACTURING AND LOADING BUILDINGS

168. General.—*a.* In operations involving the manufacture or loading of hazardous materials it is essential that buildings and facilities be planned and used with due regard for the safety of the various processes as well as for convenience of production. The regulations of this section are intended to cover the special requirements and hazards of manufacturing and loading plants.

169. Manufacturing and loading buildings.—*a. Distances.*—Intraplant distances will be used in separating explosives operating and storage buildings forming a production line. Inhabited building distances as set forth in section V will be complied with in separating production lines from each other or from other sections of the plant such as administrative, quarters, or magazine areas.

b. Ventilation.—All buildings where fumes or explosives dust are produced in must be ventilated thoroughly to prevent poisoning the operators.

c. Heat.—When heating is required in buildings containing explosives it will be direct or indirect, depending upon the character of the explosives in the building.

d. Air conditioning.—Air conditioning of operating buildings should be installed in accordance with applicable portions of the National Board of Fire Underwriters' regulations for Air Conditioning, Warm Air Heating, Air Cooling and Ventilating Systems, and shall satisfy such local requirements as may be prescribed by the commanding officer relative to installations in hazardous locations.

e. Electric power and light.—(1) Electric motors will not be located in rooms or buildings containing explosives, dust from explosives, vapors from which explosives may condense, inflammable vapors or dust which may form explosive or inflammable mixtures with air unless such use is given specific approval by the Chief of Ordnance. Motors normally should be located outside of buildings containing these substances with no connection to the process building except through mechanical power transmission and control devices which pass through glands or apertures adequately sealed against egress of the hazardous material in the building.

(2) Lighting installations for illuminating rooms or buildings containing explosives, dust from explosives, or vapors from which explosives may condense normally should be mounted at adequate distances from the building and should be designed to shine through panels such as approved in paragraph 169*f*.

Lighting installations may be located in such rooms or buildings when approved by the Chief of Ordnance.

(3) Electric lighting installations located in rooms or buildings containing inflammable vapors or dust which may form explosive or inflammable mixtures with air will comply with the requirements of the National Electrical Code or will be approved by the Chief of Ordnance.

(4) The detailed requirements for lighting fixtures for hazardous locations prescribed in applicable Ordnance safety bulletins will be observed.

f. Windows.—(1) In explosives or other hazardous areas the windows are preferably of wire glass. Measurable protection from broken glass may be secured by screens backed or supported by heavy wire netting. This, of course, results in the reduction of illumination from the window thus protected. Woven copper wire screens, 16-mesh, backed up by 2-mesh galvanized wire cloth, have been found practicable for this purpose.

(2) The use of screen and wire mesh for buildings within operating lines will be based on the location of windows being considered, and the numbers of persons regularly employed in the vicinity of the windows.

(3) The use of screen and wire mesh for protection against glass in skylights is mandatory.

(4) Screen and wire mesh for the protection of persons in buildings at inhabited building distances from operating lines ordinarily will not be required except in special cases where they are considered necessary because of such considerations, as peculiar topography, or the exposure of great numbers of people behind large windows directly facing dangerous buildings.

g. Doors.—(1) All exits should be marked plainly, and care should be taken that they remain unobstructed at all times. Outside doors must open outward. Safety doors, required in all buildings containing explosives, should be double doors glazed with clear wire glass. In no case should the opening be less than 2 feet 6 inches by 6 feet 6 inches. During operating hours, in all cases, they must be fastened with antipanic catches only. All interior doors must be in the normal line of the flow of material and open in the direction of the flow of material.

(2) Safety doors which are higher than 4 feet above the ground should be provided with safety chutes, stairways, or inclined ramps.

h. Safety chutes.—(1) Safety exits must open on a platform not less than 3 feet wide. Safety chutes will begin at the outside edge of the platform and not at the edge of the building. Landings from safety chutes must be located at protected places. If the end of the chute is constructed parallel with the ground, the passage of the person using the chute will be slackened sufficiently to obviate the need of a landing cushion. Cushions are unsatisfactory during winter in cold climates because they freeze. Exits must lead directly to routes which permit escape from the vicinity of the building itself. These routes must be free from tripping hazards, low guy lines, or other obstructions.

(2) Chute ends must not be over 24 inches above the ground. If necessary, the end of the chute must have a horizontal run sufficient to prevent injury of the employee due to speed of exit.

(3) The following safety-chute dimensions are recommended: Angle, 30° to 40° from horizontal; depth of chute, 24 inches; radius of bottom of chute, 12 inches. Chutes under 15 feet require no horizontal section. Chutes 40 feet in length require 6 feet of horizontal section, with the juncture well rounded. The sheets of metal of which the chute is constructed must lap in the direction of travel.

i. Fire escapes.—Fire escapes are required only in buildings of two stories or higher and only where other suitable emergency exits are not provided.

(1) Every floor requiring fire escapes should have at least two widely separated exits, preferably located in opposite sides of the room or building, and clearly marked "fire escape." Where fire escapes are required they should be of fireproof construction, with admittance only from windows or doors glazed with wire glass.

(2) Outside fire escapes, except safety chutes, are inferior to stairways as means of escape. When constructed they should be located on dead walls, with no opening other than windows or sash doors glazed with wire glass.

(3) Stairs should not be less than 22 inches in width. Capacity should be computed on the basis of 22 inches for every 14 people who would use it in an emergency.

j. Stairways.—Stairways must have handrails, and long stairways should have landings and turns. The construction of winding or spiral stairways should be avoided. For a rise less than 20° an incline or ramp should be used. For a rise between 20° and 50° stairways are required. Landings should be the same width as stairways and not less than 3 feet in length.

k. Platforms, runways, and railings.—Platforms or runways are required wherever employees are required to go into places where injury may result from falls or from contact with moving machinery or other objects.

(1) Platforms and runways require at least one stairway or fixed ladder. Platforms or runways exceeding 80 feet in length, or 250 square feet in area, require two stairways or ladders. Platforms or runways should be designed with a minimum strength of 50 pounds per square foot.

(2) Platforms or runways around tanks should be built at least 3 feet 6 inches below the top of the tanks.

(3) Platforms, floor openings, runways, stairways, tanks, or open vats, the tops of which are less than 3 feet above the floor of the building or platform, and other places where the hazard could be minimized by a railing, must be guarded by suitable railings consisting of handrails, midrails, and toe boards.

(4) Permanent railings should be of metal, except in process buildings, where metal railings would increase the hazard. Toe boards are not required on platforms or runways around tanks or vat tops which are 6 inches or more above the floor of the building or runway.

(5) Railings, platforms, and runways must be made of first-class materials and constructed in a substantial manner.

l. Ladders.—(1) Permanent ladders of either metal or wood require a minimum back clearance of 24 inches, a minimum front clearance of 6 inches, and a minimum side clearance of 12 inches. When possible, these dimensions should be increased. Permanent ladders should extend 3 feet 6 inches above landings. Landings or platform spaces should not be over 16 feet apart. Ladders and cages around the platform should be constructed of first-class material in a workmanlike manner. Where a ladder inclines more than 1 foot in 6 feet, it should be replaced with a stairway.

(2) Portable ladders of the wall, platform or step type, all scaffolding of the assembly type, and all ladder planks of the fixed length type or the extension type must be purchased with the idea of use and safety, rather than of cost.

(a) All ladders and similar related equipment should be purchased and delivered in the unpainted condition. After inspection for knots, checks, and cracks, they should be stenciled for department, specific use and other identifying information and then painted with two or more coats of linseed oil.

(*h*) All repairs to ladders and related equipment should be so made as to place the ladders in their original conditions as nearly as possible. Improvised repairs and improvised ladders are prohibited in Ordnance establishments.

(*c*) All platform and stepladders will be so constructed as to permit the tightening up of side rails and treads by suitable means originally incorporated in the ladder design.

(*d*) Extension ladders will be used as extension ladders and not as two or more single ladders.

(*e*) Frequent inspections will be made of all ladders and ladder equipment, both as to condition and as to utilization.

(*f*) Where portable ladders are used regularly and often for the same operation, they should be replaced by permanent ladders.

(*g*) Portable ladders will be equipped with nonslip ladder shoes, bracings, cleats, or will be planted in the ground, or held by an employee.

m. Cranes.—(1) A capacity plate showing capacity of hoists in pounds or tons must be posted in a protected and conspicuous place on each crane. The plate must show the lift capacity of the hoist or crane under varying conditions.

(2) Parts of lifts and fastenings must be inspected weekly and an inspection report filed with the resident safety engineer monthly.

(3) Locomotive cranes and derricks must be equipped with effective outriggers and rail clamps.

n. Elevators.—The following rules apply only to elevators carrying passengers or an operator.

(1) Carrying capacity must be posted at all entrances to the elevator and in the elevator.

(2) Elevators and all elevator equipment must be inspected weekly and an inspection report filed with the resident safety engineer monthly.

(3) Elevators must be of a safety type with safety catches, automatic limit stops, and emergency exits. The gate or door must be guarded securely by approved gates or hatchways. Gates or doors must be arranged so that the elevator will not start until the gate or door to the elevator has been closed. Devices giving equal security are acceptable.

(4) Electrical power and lighting installations will be in accordance with the provisions of paragraph 109*c*.

o. Drowning and deluge systems.—Satisfactory drowning tanks and arrangements for complete and rapid drowning or deluging must be provided for all hazardous process materials which are likely to fume, burn, or to decompose quickly. Automatic and hand-controlled deluge systems will be installed at any location where an incipient fire may be quenched by the instant deluge of water started by an operator, or the fusing of the link nearest to the fire. Installations must conform to applicable portions of National Board of Fire Underwriters' Standards for Sprinkler Equipments.

(1) Melting kettles, cotton pickers, powder cutters, and other machinery or processes, in which there is a process fire hazard, should be equipped with hand-operated, quick, or instant control deluge systems in addition to an automatic device.

(2) The deluge system will be charged with steam, water, or chemicals, depending upon the character of the fire to be controlled.

p. Agitation.—Nitrators, washers, and other machines which, because of the hazard of the process and the likelihood of decomposition of the process material, are provided with mechanical agitators, should have two means of agitation, each operated from an independent source of power.

q. Tunnels.—Whenever tunnels are used for pipes or passageways they must be provided with a sufficient number of exits. They must be well lighted, drained, and ventilated. Live steam lines in tunnels must be installed with care; they must be well anchored and have necessary provision for expansion and contraction.

170. Acids and inflammable materials buildings.—*a.* Buildings or housings should be built of material not actively acted upon by fumes and gases which are produced in manufacture. Stone, brick, tile, asphaltum painted concrete, acid-resisting bricks, and acid-resisting cement are acceptable materials. Carbonaceous materials affected by contact with acids, fumes, and gases, should be limited to a minimum in the construction of buildings to be used where acids will be present. Floors should be of acid-resisting material sloped to a drain connected with catch pits. If an earth floor is used, it should be covered with limestone.

b. In manufacturing buildings where acids and inflammable materials are handled, gases of a toxic, asphyxiating, or inflammable character may be found in the rooms in varying amounts, depending upon the design and efficiency of the ventilating system. In some cases this creates a fire hazard, but in all cases the efficiency of the employee is lowered in proportion to the contamination of the atmosphere in the room.

171. Storage of volatile liquids and acids.—*a.* Volatile liquids should be stored preferably in tanks in earth-covered vaults, below ground level, and at least 80 feet from the building where they will be used. However, they may be stored in tanks protected with an asbestos covering, above ground, at a safe distance from the building where they will be used. Acids are usually stored in tanks placed on piers at a convenient location near the building where they are used. Spent acid is usually collected in tanks located at a good drainage point, the acid flowing by gravity from the operating building. Liquids and acids may be conveyed from one point to another by means of air pressure or pumps. The pipe system should be so arranged that when the pump is shut down or the air valve closed the liquid will drain back into the supply tank. Gravity feed to an operating building is undesirable, owing to possible losses because of leaks in the pipe or fittings. Danger signs should be provided to indicate acid leaks. All quantity storage should be provided with earth dykes of sufficient height to confine any serious leakage.

b. All the safety standards outlined in section XX, Safety Operating Regulations for Manufacturing and Loading Plants apply also to the buildings described above.

172. Sprinkler systems.—*a.* Sprinkler systems should be installed wherever the checking of an incipient fire is desirable. The installation must conform with the standards of the National Board of Fire Underwriters for Sprinkler Equipments, as well as with other safety regulations covering special equipment. Sprinkler systems should not be installed where water will increase the fire hazard. Placards in buildings containing sprinkler systems should prohibit the storing of materials which become more hazardous in the presence of water.

b. There are two types of sprinkler systems: (1) The wet-pipe system, in which pipes are filled with water which is released when the temperature of the room rises above the fusion temperature of the link.

(2) The dry-pipe system, in which compressed air fills the pipes to the main valve, which opens when the pressure is released by the fusion of the link or leakage in the system. This latter possibility is a serious disadvantage of the system. Another dry-pipe system is provided with open-head sprinklers and a thermostatic control of the main valve which opens if there is a rapid rise in temperature.

c. The links or "heads" are made with fusion temperatures as low as 115° F. (46.1° C.), up to practically any desired limit. Openings in floors, partitions, tunnels, shafts, or any conditions which will cause a draft and prevent the concentration of heat of an incipient fire on the links, should be obviated in order for heat to cause the fusing of sprinkler heads in case of fire. Draft stops 12 inches deep should be provided at regular intervals, except where beams or girders make draft stops unnecessary.

d. In addition to the cut-off valve in the building, another valve should be provided outside of and at a safe distance from the building, in case it is impossible to enter and shut the valve inside.

e. Valves on sprinkler systems should be marked plainly and should be arranged so that there can be no confusion with the service systems of the building.

f. Pressure gages of the system should be located in prominent places, at least 1 foot above the floor. All sprinkler shut-off valves in the building should be "sealed" open.

g. A sprinkler system should draw its water directly from the water main and be independent of the service supply of the building. The system should be drained twice a year.

h. Pressures ranging from 80 to 100 pounds per square inch are recommended for sprinkler systems.

i. Periodic tests will be made of all sprinkler systems to insure their proper functioning.

173. Powerhouse installations and equipment.—Powerhouse equipment, boilers, engines, and auxiliary equipment will be installed and operated in compliance with applicable A. S. M. E. codes and National Electrical codes, and such other applicable codes, regulations, or standards as are recognized as standard practice.

174. Refrigeration plants.—Installation and equipment in refrigeration plants should be in accordance with applicable requirements of The American Standards Association Safety Code for Mechanical Refrigeration.

SECTION XXII

STORAGE AND HANDLING OF HAZARDOUS RAW MATERIALS, EXPLOSIVES, AND INFLAMMABLES

175. General.—The manufacture and loading of explosives necessitates the handling and storage of a large variety of acids and other materials, many of which possess characteristics which render them hazardous, and which require the observance of special precautions. A brief description of approved methods of handling and storage of such materials, and of their characteristic hazards is given in the following paragraphs.

176. Acetone (CH_3COCH_3).—*a. Storage.*—Permanent or reserve storage in large quantities is not recommended. Storage in steel tanks underground is considered good practice. Acetone may be shipped in iron drums, tank cars, carboys, and cans. When stored in these, special protection against fire is required. Acetone should be stored in a cool dry place not exposed to the direct rays of the sun nor located near radiators or other sources of heat.

b. Hazards.—Acetone has all the fire and explosive hazards of inflammable volatile liquids, and the degree of hazard is about equal to that of benzene and slightly less than that of gasoline. Safety tools and equipment are required in all processes involving acetone.

177. Acetylene (C_2H_2).—*a. Storage.*—Permanent or reserve storage is not recommended. It is preferably stored in specially constructed and tested steel cylinders.

b. Hazards.—There is a fire and explosion hazard when acetylene is mixed with 3 to 65 percent of air. When produced from calcium carbide it should be produced only in machines authorized by the National Board of Fire Underwriters. Fire extinguishers and sprinkler systems are recommended for buildings in which acetylene is stored. Acetylene may explode without the admixture of air. Special burners are required for its use in lighting and heating. Safety tools and equipment are required. Low percentages of acetylene with air mixture are not explosive or asphyxiating.

178. Acids, general.—The following precautions should be observed in handling, storage, and use of acids:

a. Because of the danger of glass breakage, due to sudden changes of temperature, acid carboys or bottles should not be stored in the direct rays of the sun. When a new shipment of carboys is received the stoppers should be loosened. If the bottles are full, 5 percent of the contents should be removed from each to allow for expansion.

b. Carboys in storage should rest on wooden strips. When piled in tiers care should be taken that the bottoms of the upper row do not touch the glass necks of those below.

c. Acids should not be stored in wooden buildings.

d. Departments where acids are stored or used should be kept clean and free from rubbish and all slippery places should be treated. Pails of clean water and neutralizing solutions should be placed so as to be quickly and easily available for removing acid from hands, face, or other parts of the workers.

e. Where acid fumes have a toxic, corrosive, or asphyxiating action, great care should be taken to prevent operators from being overcome or injured.

f. Goggles and respirators should be available and employees trained in their adjustment and use.

g. Metal drums or tanks containing sulphuric acid or its mixtures must not be left open. The absorption of moisture from the air creates an acid sufficiently dilute to cause rapid eating away of the container at the surface line.

h. Naked flames, lights, or work of any kind which will cause a spark must be avoided around acid stored in metal tanks. The action of acid on metal may generate explosive gas mixtures.

i. In addition to the foregoing, areas in which acids are stored or used should have the following neutralizing material available in convenient form:

(1) For neutralizing acids in quantities, slaked (hydrated) lime.

(2) For cleaning acid from floors and equipment or as may be required, 10 to 20 percent soda-ash solution. This neutralizing process gives off heat and should not be used where large quantities of acid are involved.

(3) For washes, a 10-percent solution of bicarbonate of soda.

179. Acid, hydrochloric (muriatic acid) (HCl).—*a. Storage.*—Stored in carboys or bottles, preferably in buildings provided with acid-resisting floors. Carboys of HCl should be protected against mechanical injury, and should not be stored with nitric acid and strong oxidizing substances.

b. Hazards.—In itself, hydrochloric acid offers no fire or explosive hazard. It reacts violently with zinc, iron, aluminum, and other common metals, generating heat and hydrogen gas.

180. Acid, hydrofluoric (HF).—*a. Storage.*—This acid is shipped and stored in lead carboys, rubber drums, or wax bottles. Special care must be taken to protect the containers from injury.

b. Hazards.—This acid is made by dissolving hydrogen fluoride gas in water. It is very volatile. Both the liquid and its fumes are very corrosive and attack most substances, including glass.

181. Acid, mixed.—*General properties.*—By mixed acid is meant any mixture of sulphuric and nitric acids. Nitrations are usually carried out with sulphuric and nitric acids mixed in varied proportions. Nitric acid is sometimes used alone for nitrating. Constants and properties vary with the mixture. Mixed acids containing not less than 10 percent of nitric acid will not freeze at ordinary temperatures and will not actively attack steel storage tanks.

182. Acid, waste (spent acid).—These are acids which have been used, usually in nitration. They contain small amounts of nitrated product. In the case of spent acid from glycerin nitration the hazard is considerable.

183. Acid, nitric (HNO_3).—*a. Storage.*—Nitric acid should be stored in carboys or enamel-lined tanks, but never in lead-lined tanks. When stored in the open, quantities may be unlimited; when stored in buildings, in lots of not over 100 carboys. Permanent or reserve storage is not recommended.

b. Hazards.—With organic materials it forms explosive compounds, and with most all oxidizable materials it forms inflammable compounds, some of which are subject to spontaneous combustion. Nitric-acid fires are likely to produce suffocating fumes. Good ventilation is required in buildings involving the use or manufacture of nitric acid. Space between buildings should be sufficient to give room for fire fighting and to prevent the accumulation of acid fumes. Workers in nitric acid should wear shoes, gloves, gauntlets, woolen uniforms, and aprons of impervious material.

184. Acid, sulphuric (oil of vitriol) (H_2SO_4).—*a. Storage.*—It may be stored in carboys, drums, tank cars, or glass bottles. Storage in large tanks under acid-resisting surroundings is accepted as good practice. Permanent or reserve storage is not recommended.

b. Hazards.—Strong acid chars wood, cotton, and vegetable fiber, but in so doing does not cause fire. The addition of water develops heat which may be sufficient to cause fire or explosion. Carboys of mixed acid sometimes explode, due to pressure of liberated gases. Frozen sulphuric acid in carboys is particularly difficult to handle. Sulphuric acid should not be stored with nitric acid, volatile or inflammable liquids, substances which ignite spontaneously, or with oxygen carriers.

185. Alcohol, ethyl, (grain alcohol) (C_2H_5OH).—*a. Storage.*—Permanent or reserve storage of large quantities is not recommended. It is stored preferably in large steel tanks underground or in tight steel drums in a cool place, protected by sprinkler systems. When stored in the open, exposed to direct rays of the sun and at high temperatures, water should be sprayed on the drums continuously.

b. Hazards.—The hazards are similar to those of all volatile and inflammable liquids, but are less than those of ether or gasoline.

186. Alcohol, methyl (wood alcohol) (CH_3OH).—*a. Storage.*—Same as ethyl alcohol.

b. Hazards.—Fire and explosive hazards are greater than for ethyl alcohol. Methyl alcohol is the most toxic of the alcohols and poisoning takes place as readily through the skin and lungs as through the stomach.

187. Aluminum (Al), powdered.—*a. Storage*—General warehouses. *Containers:* Cartons in wooden shipping boxes, hardwood kegs or barrels. Keep in a dry place.

b. Hazards.—Forms inflammable and explosive mixtures with air and oxidizing substances. *Containers should be safeguarded* against mechanical injury. Aluminum should not be stored adjacent to oxidizing compounds such as sodium nitrate or potassium chlorate. In case of fire do not use water as this may result in an explosion.

188. Amatol.—*a. Storage.*—Amatol is not a manufactured product, but a mixture made at the time of loading. There should be no occasion for storing. If stored, boxes lined with moisture-proof paper, holding 100 pounds net weight, are recommended.

b. Hazards.—In general, the hazards are slightly less than for TNT. Drenching systems controlled automatically and by instantaneous devices are desirable on melting kettles and other process machinery. Safety shoes and safety uniforms are required in process buildings. All practices and precautions relating to health and safety required in the handling of TNT are required in processes involving amatol.

189. Ammonia (anhydrous).—*a. Storage.*—In warehouses when contained in steel cylinders or commercial shipping containers.

b. Hazards.—May cause asphyxiation if breathed in sufficient quantities from leaky containers or pipes. Gas masks with special canisters for protection against ammonia fumes should be provided.

190. Ammonium perchlorate (NH_4ClO_4).—*a. Storage.*—In magazines for explosives, preferably in a fire-resistant type of warehouse. *Containers: Glass bottles, or iron drums.*

b. Hazards.—A fire and explosive hazard when associated with carbonaceous material or finely divided metals.

191. Ammonium nitrate (NH_4NO_3).—*a.* Ammonium nitrate is a crystalline powder varying in color from almost white to brown. It is mixed with TNT in the manufacture of amatol, which is an authorized bursting charge for ammunition. Usually, ammonium nitrate can not be detonated by heat or friction, but it may be exploded by a heavy initiation. It may be exploded by relatively light initiation if it has been sensitized by certain impurities, among which are many carbonaceous materials. Ammonium nitrate is not very inflammable at usual temperatures, but fires involving ammonium nitrate in large quantities become an explosive hazard.

b. Storage.—When stored in approved metal containers in a high explosives storage area the quantities and distances for high explosives storage will be complied with. When stored in an area with inflammable materials, which area is separated from buildings containing high explosives by inhabited building distances as set forth in section V of this manual, ammonium nitrate may be stored in accordance with the safety distance regulations for smokeless powder.

c. All manufacturing operations in ammonium nitrate lines are considered explosives operations; but the neutral liquor itself is not considered hazardous prior to the beginning of the manufacturing process. Although there are records of explosions in highly concentrated liquor being processed in the high pans, there is no record of an explosion having occurred in the liquor in such concentrations as are necessary for successful shipment in and handling to and from tank cars.

192. Ammonium picrate (explosive D) ($NH_4C_6H_2(NO_2)_3O$).—*a. Storage.*—Stored in magazines for explosives. Containers: As given in the United States Army Specification No. 50-13-8. Boxes with moisture-proof lining, 1.27 by 1.10 by 0.90 feet, 50 pounds net weight, 60 pounds gross weight; 1.90 by 1.33 by 1.83 feet, 100 pounds net weight, 113 pounds gross weight. Also stored in kegs and barrels.

b. Hazards.—(1) In general slightly less than those for TNT. No lead in any form will be permitted in buildings handling this explosive.

(2) Sprinkler and deluge systems are recommended in connection with drying and assembling processes. Such systems will be of service in preventing the spread of fire rather than in extinguishing fires in the burning material. Fires involving large quantities of this material may result in violent explosions. Fires involving projectiles loaded with this material may be expected to detonate as soon as the fire becomes intense or the pressed explosive becomes ignited. Cleanliness in all processes involving the handling of the material is recommended.

193. Amyl acetate (banana oil) ($CH_3CO_2C_5H_{11}$).—*a. Storage.*—Permanent or reserve storage in large quantities is not recommended. It may be stored in commercial airtight metal containers.

b. Hazards.—Amyl acetate has the fire and explosive hazards of volatile and inflammable liquids in a degree somewhat greater than alcohol and less than ether or gasoline. When mixed with alcohol the hazard is increased.

194. Barium chlorate ($Ba(ClO_3)_2$).—*a. Storage.*—Shipped and stored in wooden boxes, barrels, or kegs. It should have isolated storage and should not be stored in the same building with combustible materials, acids, sulphur, powdered magnesium or powdered aluminum.

b. Hazards.—Pure barium chlorate is not sensitive to friction, but impure chlorate, or material spilled on the floor, or mixed with small amounts of impurities, becomes very sensitive to shock and friction. It is a strong oxidizing material. It forms explosives mixtures with carbonaceous materials. Water is the best agent for fighting fires involving barium chlorate.

195. Barium nitrate ($Ba(NO_3)_2$).—*a. Storage.*—In general warehouses. Containers: Iron drums or wooden barrels.

b. Hazards.—A dangerous fire hazard.

196. Barium perchlorate ($Ba(ClO_4)_2$).—*a. Storage.*—This substance is shipped and stored in wooden boxes, barrels or kegs. Isolated storage is preferable. Precautions should be taken to prevent injury to containers.

b. Hazards.—Barium perchlorate is a strong oxidizing material. It will form explosive mixtures with combustible materials such as sulphur, powdered magnesium, aluminum, and carbonaceous substances. Any spilled material must be cleaned up at once and removed from the building. For sensitiveness to friction, see Barium Chlorate.

197. Barium peroxide (BaO_2).—*a. Storage.*—Store in tightly closed metal containers in a cool dry warehouse. Do not store with starch, sulphur, powdered metals, or other combustible materials.

b. Hazards.—Oxidizing material and dangerous fire hazard. Reacts with water to produce oxygen. Smother fire with sand, ashes, dry earth, or rock dust. Do not use water.

198. Benzene (C_6H_6).—*a. Storage.*—Permanent storage of large quantities of benzene is not recommended. It may be stored in tanks, in airtight steel drums, or carboys.

b. Hazards.—Sprinkler and deluge systems will be of service only in extinguishing fire in the building before benzene becomes inflamed. Chemical extinguishers using carbon tetrachloride, firefoam, or treated sawdust are effective against fire in benzene. Hazards in the manufacture of benzene are those of fire and explosion of materials having low flash points. Strict enforcement of lighting and power requirements, and the use of safety tools and equipment are required. The hazards of benzene are similar to those of gasoline and may be treated in much the same way. It is very toxic; exposure of personnel should be limited as much as possible. Toxic hazards comprise (1) acute poisoning through respiration of fumes and vapors, or injection of the liquid, (2) chronic poisoning through respiration over a longer period of time of small quantities of fumes or vapors; (3) dermatitis due to drying action of solvents.

199. Black powder.—*a. Hazards.*—Black powder explodes on ignition. The manufacturing process is hazardous. All precautions in the way of magnetic separation, especially dust prevention or elimination, and other safety precautions should be observed. The machinery of individual buildings should be controlled from a place of safety, and as far as possible, the driving machinery should be located behind barricades or traverses. So far as possible operators should not be allowed to enter buildings while machinery is in operation.

b. In assembly plants or loading plants, deluge systems and sprinkler systems are of value in preventing the spread of fires. Small stocks only should be carried in the loading rooms or buildings. Black-powder pellets ignite as readily as granular powder. Powder which has become dry after drenching resumes sufficient of its explosive properties to become a serious explosive hazard. Carbonaceous materials which have absorbed liquors leached from black powder constitute a high order fire hazard. Lumber or carbonaceous materials from black-powder buildings will not be released for reuse. Repairs may be made safely only by strict adherence to all safety measures.

200. Calcium carbide (CaC_2).—*a. Storage.*—Calcium carbide is shipped and stored in iron drums and tin cans. It should be stored in a dry, well-ventilated place. There is little danger in storing this material if the drums are tightly closed so that no moisture can come in contact with the carbide.

b. Hazards.—The hazard lies in the formation of acetylene gas which results when water is mixed with calcium carbide. Drums must be closed tightly to prevent the entrance of water. Water should not be used in fighting fire involving calcium carbide or carbide acetylene generators.

201. Carbon tetrachloride (CCl_4).—*a. Storage.*—Stored in metal drums or tinned cans.

b. Hazards.—Not a fire hazard. In the presence of heat, carbon tetrachloride may form hydrochloric acid and phosgene. Such conditions occur when it is used as a fire extinguisher. When absorbed into the body through the respiratory or digestive systems, it may cause severe illness and even death. Persons who are subject to alcoholism, lung, kidney, or heart trouble should not be assigned to work with carbon tetrachloride. When used openly in a shop good ventilation must be provided and respiratory equipment provided all personnel who may be affected.

202. Caustic soda (Sodium hydroxide) (NaOH).—*a. Storage.*—Stored in warehouses in airtight containers. Storage of large stocks is not recommended. It should not be stored in buildings with sprinkler systems.

b. Hazards.—Aside from its caustic and corrosive properties there is no particular hazard.

203. Charcoal.—*a. Storage.*—Permanent or reserve storage of charcoal is not recommended. Owing to its tendency to absorb gases and moisture, it is stored preferably in airtight containers. When stored in bags, the usual shipping container of bulk charcoal, it should be piled in tiers with skeleton or gridiron floors between tiers and with ample provision for ventilation. Storage in bulk is prohibited.

b. Hazards.—While charcoal is a fire hazard of high order, the hazard lies mainly in spontaneous combustion. In this respect charcoal burned in pits is less likely to spontaneous combustion than the product obtained from chemical plants. The hazard is also less in softwood than hardwood charcoal, and greater during cooling after burning or when drying after having absorbed moisture. Contact with certain materials, as, for example, alcohols and oils, increases the fire hazard. Charcoal in which fire has been extinguished is an increased fire hazard. Fumes of gases from smoldering or burning charcoal are toxic.

204. Cyclonite (Cyclotrimethylenetriniteramine) ($C_3H_6N_3(NO_2)3$).—*a. Storage.*—This compound requires the same conditions of storage as given for tetryl in paragraph 81 of this manual.

b. Hazards.—Cyclonite is a stable explosive with properties similar to those of tetryl.

205. Diazodinitrophenol ($C_6H_2(NO_2)_2N_2O$).—*a. Storage.*—Same as for mercury fulminate.

b. Hazards.—Same as for mercury fulminate.

206. Dinitrobenzene ($C_6H_4(NO_2)_2$).—*a. Storage.*—It may be stored in explosives magazines when packed in wooden boxes lined with moisture-proof paper not exceeding 100 pounds net weight to the box.

b. Hazards.—Similar to those of TNT. Very toxic.

207. Dinitrophenol ($C_6H_3(NO_2)_2(2:4)$).—*a. Storage.*—Containers: Wooden barrels.

b. Hazards.—Dangerous fire hazard. Explosive when warm. More poisonous than picric acid. When handling dinitrophenol necessary precautions should be taken to prevent poisoning, such as wearing respirators, gloves, and special clothing.

208. Diphenylamine ($(C_6H_5)_2NH$).—*a. Storage.*—It may be stored in warehouses. Authorized shipping containers: Hardwood barrels lined with kraft paper.

b. Hazards.—While combustible, the hazard appears to be slight, although definite information about its behavior in this respect is limited.

209. Ether ($(C_2H_5)_2O$).—*a. Storage.*—Permanent or reserve storage in large quantities is not recommended. It may be stored in tanks under ground or in tight metal drums in a cool place. It should not be exposed to direct rays of the sun nor located near radiators or other sources of heat.

b. Hazards.—In the manufacture of ether the hazards are those involving ether, alcohol, and sulphuric acid. The storage hazard is relatively similar to that of gasoline, and, while similar to the latter in that the gases are heavier than air, they diffuse more readily than gasoline.

210. Lead azide ($Pb(N_3)_2$).—*a. Storage.*—Similar to mercury fulminate.

b. Hazards.—This explosive is similar in physical properties to mercury fulminate, consequently the same precautions used with mercury fulminate should be exercised except that ammonium acetate and sodium bichromate are used to destroy lead azide in place of sodium thiosulphate. Nonexplosive compounds are formed by dissolving lead azide in ammonium acetate and precipitating the lead with potassium bichromate. All floors, tables, walls, and machines should be washed with a 10-percent aqueous solution of ammonium acetate, followed by a wash with a 10-percent aqueous solution of sodium bichromate, which in turn is washed off with water. All wash cloths or brushes used in applying ammonium acetate solution should be treated with

sodium bichromate solution. Fixtures should be washed with ammonium acetate, rinsed thoroughly with water and the rinsing added to ammonium acetate solution before it is decomposed with the sodium bichromate solution. An alternate procedure which should be used when economically practicable consists of destroying lead azide with a 25 percent water solution of ceric ammonium nitrate.

211. Lead styphanate ($C_6HN_3O_8Pb$).—*a. Storage.*—Shipped and stored subject to the same conditions as mercury fulminate.

b. Hazards.—Presents the same explosive hazard as mercury fulminate.

212. Magnesium (powdered) (Mg).—*a. Storage.*—Stored in general warehouse in tightly closed metal or metal-lined containers. Provision should be made to protect containers from mechanical injury.

b. Hazards.—Magnesium powder is a dangerous fire hazard. When disseminated in the air it may be exploded by means of a spark. The powder liberates hydrogen when it comes in contact with water. A fire should be smothered with dry earth, ashes, powdered talc, or similar material. Any of these materials should be applied gently as any disturbance of the burning magnesium may cause it to spread. Water should not be used in fighting magnesium fires, except in those cases in which a "fog nozzle" is used to protect firemen or to purposely accelerate burning. The use of fog nozzles should be limited to small quantities of magnesium.

213. Match, quick.—*a. General properties.*—Quick match is a fast-burning fuse; positive, and easily ignited. It burns more rapidly than safety fuse. Designated by the number of strands (as 6-ply). Military use: In the manufacture of certain primers or igniters. Produced by impregnating cotton wicking with meal (black) powder.

b. Storage.—It may be stored in fuze and primer magazines when packed in metal-lined airtight containers.

c. Hazards.—Aside from the black powder (bulk) used in the manufacture, the hazard is one of fire. (See Black Powder.) Precautions lie principally in maintaining cleanliness and having only small stocks of powder and finished material on hand.

214. Match, slow.—*a. General properties.*—Slow match is an easily ignited slow-burning fuse. Rate of burning approximately 1 inch in 10 to 15 minutes. Produced by steeping hemp yarn in concentrated potassium nitrate liquor.

b. Storage.—It may be stored in general warehouses when packed in metal-lined airtight containers.

c. Hazards.—Involves no explosive hazard. Burns slowly. Fires in slow match are extinguished with difficulty.

215. Mercury fulminate ($HgC_2N_2O_2$).—*a. Storage.*—Must be stored alone or with lead azide or similar compounds. Must not be stored dry and not exposed to the direct rays of the sun. Mercury fulminate may be stored in shipping containers only as an expedient, and then must be stored in frostproof vaults with barrels on end, one tier high with passageway for inspection and handling. For service storage, glazed earthenware crocks with covers of ample size to hold the double bag of mercury fulminate must be used. Bags may be stored in earthenware crocks under distilled water to which alcohol has been added in the proportion necessary to prevent freezing. For use between service storage and dry houses, leather or rubber pouches will be used. Storage in manufacturing magazines will be in crocks filled with distilled water. Shipping container: Double bag of dry mercury fulminate, with 25 percent water, suspended in a hardwood barrel packed solidly with wet sawdust.

b. Hazards.—All precautions required for protection of magazines apply. It should not be handled when frozen. Wet fulminate of mercury or wet floor coverings containing small quantities of fulminate may be burned on windrows of inflammable material. Nonexplosive products are formed by neutralizing with cold sodium *thiosulphate* ($Na_2S_2O_3$). *All floors, tables, and walls in* rooms in which the dry explosive is used should be washed with this solution. In the manufacturing of mercury fulminate the fumes given off are toxic and inflammable. Care is required to prevent fulminate dust from being carried off in the exhaust system. Deposits thus made have caused explosions. Much attention should be given to cleanliness, as foreign or gritty materials in the product may cause an explosion. The floors of rooms in which dry fulminate is handled should be covered with 1/16-inch cloth-inserted rubber packing, or equal. All cracks and crevices should be covered. The walls of these rooms should be covered with glazed waterproof material. Frequent washing with neutralizing solution is necessary. The fulminate is dried in muslin squares on a drying table. The drying tables may be heated with hot water, or the dry house by a warm-air blower system. The drying temperature should be between 50° C. and 60° C.

Primer caps and detonators loaded with fulminate of mercury are less sensitive than the dry bulk material, but must be handled with great care. Fires involving these assemblies should be treated the same as the bulk material. They will explode as soon as fire reaches the fulminate. Stocks in assembly or loading rooms should be kept as small as possible.

216. Mononitronaphthalene ($C_{10}H_7NO_2$).—*a. Storage.*—Mononitronaphthalene is shipped and stored in wooden barrels and kegs. It is used as an ingredient in trimonite, as a dye intermediate, and as an active ingredient in some commercial explosives.

b. Hazards.—Mononitronaphthalene presents no fire hazard in storage, but it has the same toxic hazard as other aromatic nitrocompounds.

217. Motion-picture film.—*a.* Motion-picture film (except noninflammable film) should be stored in a cool, well-ventilated building of fireproof construction. "No smoking" rules should be enforced strictly. All electrical and heating equipment should be safeguarded. Any artificial heating should be restricted to steam or hot water. Quantities of less than 25 pounds may be kept in I. C. C. shipping containers, but more than 25 pounds should be stored in standard ventilated cabinets.

b. Hazards.—Possesses unusual burning characteristics. Has a high degree of inflammability and is subject to exothermic decomposition. All film should be kept in closed containers except what is actually being worked on. The amount exposed should be kept to a minimum. Scrap film should be kept separate from waste paper and rubbish, preferably under water. Burning film produces toxic fumes which may prove fatal when breathed into the lungs. Personnel fighting fires in motion-picture film will be provided with suitable protective equipment.

218. Nitrocellulose (nitrocotton).—*a. Gun cotton.*—This is the most highly nitrated cotton. Its nitrogen content is 13 percent or over. Soluble in acetone, but only slightly soluble in ether-alcohol mixtures.

b. Pyrocotton.—Nitrated cotton having a nitrogen content of 12.5 to 12.7 percent. Entirely soluble in ether-alcohol.

c. Pyroxylin.—Nitrated cotton with a nitrogen content usually less than 12.5 percent. Soluble in amyl acetate.

d. Of these, pyrocotton is of primary interest from a military point. Pyrocotton is the base of smokeless powder. When dry it is sensitive to shock and friction. It is highly inflammable and explosive; burns rapidly without smoke and leaves no residue.

c. Storage.—Nitrocellulose containing 20–35 percent moisture is stored in zinc-lined boxes or metal drums. Storage of dry nitrocellulose is not permitted as it is attended with all the hazards of a sensitive and easily ignited high explosive.

f. Hazards.—(1) Fires involving wet nitrogen may be fought without fear of explosion. Fires involving dry nitrocotton usually are followed by detonation of the entire mass.

(2) Nitration involves fire and fume hazards in addition to those incident to the handling of acids only. Efficient ventilating systems and safety exits are required for the operators. Nitration buildings should have all safety appliances and standards required under "Safety standards," such as neutralizing solutions, automatic sprays, and, as far as possible, shoes, aprons, gloves, etc., impermeable to acids.

(3) In the boiling, beating, pouching, and wringing processes the hazards may be those of dry nitrocotton due to process material which has become dry. Protection against this hazard lies in cleanliness. Low-temperature heating medium only should be used in these process buildings.

(4) The drying of nitrocellulose by the fan system of warm-air circulation involves considerable hazard. It will be resorted to only for drying small quantities for experimental purposes where the usual method of dehydrating may not be applicable. Dry nitrocellulose is not only very easily ignited and highly sensitive to friction or impact, but readily accumulates static charges. Trays used for drying must be well grounded. The flow of air should be carefully controlled and the temperature not allowed to exceed 38° C. Drying must be conducted in a special, well-isolated dry house, which must be thoroughly washed out after each charge. All persons entering the dry house must wear safety shoes and safety clothes. No tools will be permitted to remain in the dry house.

219. Nitroglycerin (NG) ($C_3H_5(ONO_2)_3$).—*a.* Nitroglycerin usually is manufactured only as required in manufacturing operations. It is stored for more or less immediate use in special nitroglycerin storehouses, which are process buildings. It is kept under constant surveillance until it is used.

b. Hazards.—The manufacturing processes are hazardous. State laws usually require the stages of manufacturing process to be carried out in separate buildings, the material being allowed to flow from one building to the next through lined gutters. During nitration, cooling is imperative. Drowning tanks must be provided to receive the mixture should the temperature rise to the danger point. Utmost cleanliness is required. Floors should be covered with lead and be without crevices of any kind. The lead floor covering should be carried to the height of the baseboard. All joints must be "lead burned." Small quantities of nitroglycerin may be neutralized or destroyed with sodium sulphite-wood alcohol solution.' All machinery, equipment, and tools are "special" in that they are designed for the particular process and with full consideration of safety features. Frozen nitroglycerin is particularly difficult to handle. During thawing, internal changes may take place which are accompanied by evolution of heat sufficient to cause an explosion. Nitroglycerin cannot be shipped by freight or express.

220. Oxygen (O).—*a. Storage.*—By itself in open shade. Containers: Tested steel cylinders of special construction.

b. Hazards.—A dangerous fire hazard.

221. Oil, linseed.—*a. Storage.*—In general warehouses. Containers: Tinned cans and hardwood barrels.

b. Hazards.—Fires from spontaneous combustion have been caused from linseed oil, soaked rags, and cotton waste.

222. Paints, enamels, varnishes, lacquers, japans, and dopes.—*a. Storage.*—In general warehouses. Containers: Cans, drums, or hardwood barrels. May not be stored nor used near open fires.

b. Hazards.—Always a fire hazard. Paints with driers are an explosive hazard. In buildings where paints and oils are used in connection with manufacturing or assembling process, stocks should be kept at a minimum and a system of ventilation controlling all vapors should be a part of the installation. Sprinkler and deluge systems are not recommended except as a control of secondary fires. Firefoams, pyrene, carbon dioxide, carbon tetrachloride, and treated sawdust, are effective fire extinguishers; water is not effective as an extinguisher for large oil fires.

223. Phenol (carbolic acid) (C_6H_5OH).—*a. Storage.*—Should be stored in general warehouses. For permanent or reserve storage extra quality drums should be used, e. g., iron lined with chemical lead.

b. Hazard.—When manufactured from benzene the hazards of benzene and its vapors are included. Benzene tanks should be located underground. Careful control of temperature in the sulphonating process is required so that vaporization rate is not excessive. The possibility of unsulphonated benzene in the secondary process should be precluded. Provision for taking care of fires in melting pot should be made. The melting house should be preferably of fire-resistant material. Lime storage must be entirely separate from process buildings. The dissolving and distillation process should be carried out in a detached building; automatic shut-off on connections should be installed.

224. Phosphorous (P).—*a. White phosphorus.*—(1) *Storage.*—Preferably in small quantities in isolated building. Containers: Submerged in water in sealed metal vessels inclosed in wooden boxes or in metal drums. Must be kept above freezing temperature to avoid bursting of containers with resulting fire on exposure of the phosphorous to air.

(2) *Hazards.*—Dangerous fire hazard.

b. Red phosphorus.—(1) *Storage.*—In general warehouses. Containers: Iron drums or sealed metal containers inclosed in wooden boxes.

(2) *Hazards.*—Forms very sensitive mixtures with oxidizing agents. A dangerous fire hazard.

225. Pentaerythritetetranitrate (PETN) ($C(CH_2NO_3)_4$).—*a. Storage.*—Must be packed wet with not less than 40 percent by weight of water in metal barrels, drums, wooden barrels, or kegs, in which the material is packed in cloth or rubber bags.

b. Hazards.—In general, they are the same as for tetryl, except that this material is more sensitive than tetryl, but not as sensitive as mercury fulminate.

226. Picric acid (trinitrophenol) ($C_6H_2(NO_2)_3OH$).—*a. Storage.*—Picric acid may be stored either wet or dry in magazines.

b. Hazards.—The hazards of manufacture include those of handling of various raw materials. Drowning, deluge, and automatic sprinkler systems are successfully used in the manufacture and handling of this material. In the nitration processes ample ventilation must be provided. Tests of dry picric acid show that fires involving this explosive may be extinguished with automatic sprinkler systems even after the explosive has been well ignited. Although large quantities of dry picric acid have been known to burn completely without explosion, the possibility of burning resulting in detonation should not be overlooked. When projectiles loaded with picric acid are involved in a fire, detonation of the confined heated explosive is certain. Safety shoes and safety clothes are required in the manufacture and handling of this material. Safety shoes are required in buildings where the bulk material is being stored, either in wet or dry form.

227. Potassium chlorate ($KClO_3$).—*a. Storage.*—Same as for barium chlorate.

b. Hazard.—Same as for barium chlorate.

228. Potassium nitrate (niter, saltpeter) (KNO3).—*a. Storage.*—In warehouses preferably of the fire-resistant type. Commercial containers. Barrels lined with moisture-proof paper.

b. Hazards.—It is not readily inflammable but when heated provides oxygen for violent combustion or explosions when associated with inflammable or combustible materials. It is especially hazardous when stored with oils, tallows, sulphur, jute, fibrous materials, acids, and carbonaceous material, such as bags, boxes, or lumber. Carbonaceous material which has become impregnated with nitrate liquors is highly inflammable and subject to spontaneous combustion. Owing to its high melting point, explosions occur if water comes in contact with the fused material. For this reason water should not be used on fires in which it is involved, unless the fire is small and the available amount of water is large. Fire extinguishers for use in connection with the material should be charged with carbon tetrachloride.

229. Potassium perchlorate ($KClO_4$).—*a. Storage.*—Same as for barium perchlorate.

b. Hazards.—Same as for barium perchlorate.

230. Smokeless powder, pulverized.—*a. General properties.*—Smokeless powder, pulverized, is finished smokeless powder which has been ground or comminuted into a finely divided condition. In this condition, when dry, it is a high explosive; drop test, 8 inches (2 kilograms weight); rate of detonation, 4,500 M. P. S.

b. Storage.—It may be stored with not less than 20 percent of water in magazines, packed in metal-lined airtight containers similar to wet nitrocellulose.

c. Hazards.—It is safely pulverized in a water-saturated condition.

231. Sodium chlorate ($NaClO_3$).—*a. Storage.*—Same as for potassium chlorate.

b. Hazards.—Strong oxidizing compound. Similar to potassium chlorate.

232. Sodium nitrate (nitrate of soda) ($NaNO_3$).—*a. Storage.*—It may be stored in bulk in well-built, moisture-proof, preferably fire-resistant storage, or in bags, preferably under like conditions. Sprinkler and drenching systems should not be used in connection with the storage of this material. It should not be stored in frame buildings or with other combustible material. Blasting of caked nitrate of soda when stored in bulk (without bags) is not considered hazardous.

b. Hazards.—When stored alone the hazards connected with sodium nitrate are negligible. When stored in connection with inflammable material, such as the bags in which it is received, or a building of frame construction, the fire hazard is considerable. Fires in piles of bagged material which originated in the interior of piles through attempts to loosen the material by blasting have been difficult to extinguish. Due to the high temperatures developed in sodium nitrate fires, water used for extinguishing such fires has caused severe steam explosions. Burning sodium nitrate also releases toxic fumes which may prove fatal if breathed. Personnel fighting such fires will be provided with suitable protective equipment.

233. Sodium perchlorate ($NaClO_4$).—*a. Storage.*—Same as for potassium perchlorate.

b. Hazards.—Oxidizing material. Classed with potassium perchlorate with respect to fire and explosion hazards.

234. Strontium chlorate ($Sr(ClO_3)_2$).—*a. Storage.*—Same as for potassium chlorate.

b. Hazards.—Strong oxidizing agent. Same as for potassium chlorate.

235. Strontium nitrate ($Sr(NO_3)_2$).—*a. Storage.*—Store in a dry place and prevent contact with combustible material.

b. Hazards.—Strong oxidizing compound. The wood of barrels or boxes may become impregnated with the nitrate, in which condition they *may* be readily ignited.

236. Strontium peroxide (SrO_2).—*a. Storage.*—Store in tightly closed metal containers in a cool, dry warehouse. Do not store with starch, sulphur, powdered metals, or other similar combustible material.

b. Hazards.—Oxidizing material. Reacts with water to produce oxygen. Smother fire with sand, ashes, dry earth, or rock dust. Do not use water.

237. Sulphur (S).—*a. Storage.*—It may be stored in bulk or in shipping containers in warehouses, but preferably in independent buildings. Shipping containers: Preferably wooden barrels coopered with steel.

b. Hazards.—Ignites readily by flame. In small quantities burns slowly, with a relatively cool flame, forming sulphur dioxide (SO_2), a suffocating gas. In the presence of carbon, lampblack, fats, and oils it may promote spontaneous combustion. With chlorates and phosphates, or other oxidizing substances it forms highly sensitive explosive compounds.

238. Thermit.—*a. Storage.*—General warehouses. Containers: Iron drums.

b. Hazards.—A fire hazard. Cannot be extinguished with water or chemicals. Control lies in holding fires ignited by thermit in check until the molten matériel has cooled off.

239. Toluene (toluol) ($C_6H_5CH_3$).—*a. Storage.*—Same as for benzene.

b. Hazards.—Same as for benzene.

240. Tridite.—*a. General properties.*—Tridite is an arbitrary name given to a bomb and projectile explosive composed of a mixture of picric acid and dinitrophenol. The melting point is between 85° C. and 90° C. The specific gravity is 1.64.

b. Storage.—Tridite, if manufactured and boxed, will be stored in standard explosives boxes, lined with waterproof paper, in explosives magazines.

c. Hazards.—Similar to picric acid and dinitrophenol hazards.

241. Trimonite.—*a. Storage.*—Same as required for picric acid.

b. Hazards.—Same as for picric acid, TNT and other high explosives.

242. Trinitrobenzene ($C_6H_3(NO_2)_3$).—*a. Storage.*—Same as required for TNT.

b. Hazards.—Explosive and toxic hazard similar to TNT.

243. Turpentine ($C_{10}H_{16}$).—*a. Storage.*—In general warehouses. Containers: Cans and hardwood barrels.

b. Hazards.—A dangerous fire hazard.

244. Xylene ($C_6H_4(CH_3)_2$).—*a. Storage.*—Same as for benzene.

b. Hazards.—Same as for benzene.

231. Sodium chlorate ($NaClO_3$).—*a. Storage.*—Same as for potassium chlorate.

b. Hazards.—Strong oxidizing compound. Similar to potassium chlorate.

232. Sodium nitrate (nitrate of soda) ($NaNO_3$).—*a. Storage.*—It may be stored in bulk in well-built, moisture-proof, preferably fire-resistant storage, or in bags, preferably under like conditions. Sprinkler and drenching systems should not be used in connection with the storage of this material. It should not be stored in frame buildings or with other combustible material. Blasting of caked nitrate of soda when stored in bulk (without bags) is not considered hazardous.

b. Hazards.—When stored alone the hazards connected with sodium nitrate are negligible. When stored in connection with inflammable material, such as the bags in which it is received, or a building of frame construction, the fire hazard is considerable. Fires in piles of bagged material which originated in the interior of piles through attempts to loosen the material by blasting have been difficult to extinguish. Due to the high temperatures developed in sodium nitrate fires, water used for extinguishing such fires has caused severe steam explosions. Burning sodium nitrate also releases toxic fumes which may prove fatal if breathed. Personnel fighting such fires will be provided with suitable protective equipment.

233. Sodium perchlorate ($NaClO_4$).—*a. Storage.*—Same as for potassium perchlorate.

b. Hazards.—Oxidizing material. Classed with potassium perchlorate with respect to fire and explosion hazards.

234. Strontium chlorate ($Sr(ClO_3)_2$).—*a. Storage.*—Same as for potassium chlorate.

b. Hazards.—Strong oxidizing agent. Same as for potassium chlorate.

235. Strontium nitrate ($Sr(NO_3)_2$).—*a. Storage.*—Store in a dry place and prevent contact with combustible material.

b. Hazards.—Strong oxidizing compound. The wood of barrels or boxes may become impregnated with the nitrate, in which condition they may be readily ignited.

236. Strontium peroxide (SrO_2).—*a. Storage.*—Store in tightly closed metal containers in a cool, dry warehouse. Do not store with starch, sulphur, powdered metals, or other similar combustible material.

b. Hazards.—Oxidizing material. Reacts with water to produce oxygen. Smother fire with sand, ashes, dry earth, or rock dust. Do not use water.

237. Sulphur (S).—*a. Storage.*—It may be stored in bulk or in shipping containers in warehouses, but preferably in independent buildings. Shipping containers: Preferably wooden barrels coopered with steel.

b. Hazards.—Ignites readily by flame. In small quantities burns slowly, with a relatively cool flame, forming sulphur dioxide (SO_2), a suffocating gas. In the presence of carbon, lampblack, fats, and oils it may promote spontaneous combustion. With chlorates and phosphates, or other oxidizing substances it forms highly sensitive explosive compounds.

238. Thermit.—*a. Storage.*—General warehouses. Containers: Iron drums.

b. Hazards.—A fire hazard. Cannot be extinguished with water or chemicals. Control lies in holding fires ignited by thermit in check until the molten matériel has cooled off.

239. Toluene (toluol) ($C_6H_5CH_3$).—*a. Storage.*—Same as for benzene.

b. Hazards.—Same as for benzene.

240. Tridite.—*a. General properties.*—Tridite is an arbitrary name given to a bomb and projectile explosive composed of a mixture of picric acid and dinitrophenol. The melting point is between 85° C. and 90° C. The specific gravity is 1.64.

b. Storage.—Tridite, if manufactured and boxed, will be stored in standard explosives boxes, lined with waterproof paper, in explosives magazines.

c. Hazards.—Similar to picric acid and dinitrophenol hazards.

241. Trimonite.—*a. Storage.*—Same as required for picric acid.

b. Hazards.—Same as for picric acid, TNT and other high explosives.

242. Trinitrobenzene ($C_6H_3(NO_2)_3$).—*a. Storage.*—Same as required for TNT.

b. Hazards.—Explosive and toxic hazard similar to TNT.

243. Turpentine ($C_{10}H_{16}$).—*a. Storage.*—In general warehouses. Containers: Cans and hardwood barrels.

b. Hazards.—A dangerous fire hazard.

244. Xylene ($C_6H_4(CH_3)_2$).—*a. Storage.*—Same as for benzene.

b. Hazards.—Same as for benzene.

PART IV

SPECIAL SAFETY REGULATIONS FOR THE STORAGE AND HANDLING OF CHEMICAL AMMUNITION

Section XXIII

GROUPS OF CHEMICAL AMMUNITION

245. Definition of "chemical ammunition."—The term "chemical ammuntion" is used to designate a variety of forms of artillery shell, chemical mortar shell, livens projector shell, airplane bombs, grenades, candles, and containers which contain chemicals and cannot be classified properly as high explosives or shrapnel. The main types are:

a. Artillery shell, chemical and smoke filled.
b. Chemical shell, chemical and smoke filled.
c. Airplane bombs, chemical, smoke, and incendiary filled.
d. Grenades, chemical and smoke filled.
e. Containers, chemical and smoke filled.

246. Grouping of fillings.—For the purpose of storage, chemical ammunition is divided into four groups according to the nature of the fillings. Not all of the fillings listed in the accompanying tabulation are used currently as shell fillers, but may be encountered. The groups, together with their fillings and markings, are as follows:

CWS symbol	Name	Markings	
		Present	Old
	GROUP A—PERSISTENT VESICANTS		
HS	Mustard	HS-GAS, and 2 bands (all in green).	3 red bands.
M-1	Lewisite	M-1-GAS, and 2 bands (all in green).	None.
	GROUP B—TOXIC AND SMOKE [1]		
DM	Adamsite	DM-GAS, and 1 band (all in red).	"DM TOXIC."
CA	Brombenzylcyanide [2]	------------	GAS-CA, and 2 bands (all in green).
CN	Chloracetophenone	CN-GAS, and 1 band (all in red).	"CN" in red, or "CN" and 2 red bands.

See footnotes at end of table.

CWS symbol	Name	Markings	
		Present	Old
	GROUP B—TOXIC AND SMOKE—continued		
CI	Chlorine	CI-GAS, and 1 band (all in green).	None.
PS	Chlorpicrin	PS-GAS, and 2 bands (all in green).	1 red and 1 white band.
NC	Chlorpicrin-stannic chloride.[2]		GAS-NC, and 2 bands (all in green).
DA	Diphenylchlorarsine	DA-GAS, and 1 band (all in red).	1 white band.
CG	Phosgene	CG-GAS, and 1 band (all in green).	2 white bands.
KJ	Stannic chloride[2]		GAS-KJ, and 1 band (all in green).
FS	Sulfur trioxide-chlorsulfonic acid mixture.	FS-SMOKE, and 1 band (all in yellow).	None.
FM	Titanium tetrachloride	FM-SMOKE, and 1 band (all in yellow).	2 yellow bands.
CNS	Chloracetophenone solution.	CNS-GAS, and 1 band (all in red).	None.
CNB	Chloracetophenone solution.	CNB-GAS, and 1 band (all in red).	None.
	GROUP C—SPONTANEOUSLY INFLAMMABLE AGENTS		
WP	White phosphorus	WP-SMOKE, and 1 band (all in yellow).	1 yellow band.
	GROUP D—INCENDIARY AND READILY INFLAMMABLE AGENTS[3]		
TH	Thermit	TH-INCENDIARY, and 1 band (all in purple).	"THERMIT."
HC	Hexachlorethane burning mixtures.	HC-SMOKE, and 1 band (all in yellow).	None.
CN	Burning mixtures of CN	CN-GAS, and 1 band (all in red).	None.
DM	Burning mixtures of DM	DM-GAS, and 1 band (all in red).	None.
CN-DM	Burning mixtures of CN and DM.	CN-DM-GAS, and 1 band (all in red).	None.

[1] CN and DM as listed in group B refers to these chemicals in bulk or as chemical filling in shell.

[2] Brombenzylcyanide, stannic chloride, and chlorpicrin-stannic chloride have been declared obsolete, but small quantities of these materials are still in storage and, therefore, it is considered desirable to retain them in this table. The present markings for these items will be changed to old markings, and there will be no present markings.

[3] *In Group D the chemicals are mixed with small-grain smokeless powder as a filling for grenades.*

SECTION XXIV

GENERAL RULES FOR STORAGE OF CHEMICAL AMMUNITION

247. General rules.—*a.* The general rules for magazines and storage will be followed as set forth in part I of this manual, with the additions and exceptions as hereinafter stated. Detailed instructions covering chemical ammunition may be found in FM 3-15, Chemical Warfare Service Field Manual.

b. Whenever possible, each kind of material will be stored *separately*. However, unless prohibited herein, chemical ammunition items of the same group (sec. XXIII) may be stored together. Chemical ammunition of two or more groups of fillings will not be stored together except upon specific approval of the Chief of Ordnance.

c. Chemical ammunition will be stored in accordance with current ordnance drawings except for those lots for which special instructions are issued by the Chief of Ordnance.

d. Ammunition will be handled carefully. It must not be dropped or unnecessarily jarred. The same mechanical equipment for handling may be used as indicated for high-explosive shell of the same size and weight.

e. In any temporary emergency, necessitating storage outdoors overnight or for a longer period, chemical ammunition will be covered with a tarpaulin to protect it from the direct rays of the sun and from rainfall. Ammunition will be piled to permit free circulation of air.

f. Chemical ammunition must be inspected at regular intervals—at least semiannually—to determine the condition of the paint, or other rust-preventing covering. If deterioration is found, immediate corrective measures will be taken, as outlined in paragraph 258.

g. The 1-ton containers should be stored, preferably under a shed or other open-side protection, to allow handling with a crane. The shed should be of sufficient size to protect containers from rain. If stored in an open shelter, containers must be supported above the ground.

248. Report on leaking ammunition.—*a.* Any chemical ammunition found to be damaged or leaking, will be reported immediately to the officer in charge of the magazines.

b. A report will be made to the Chief of Ordnance on all chemical ammunition found in a damaged or leaking condition. This report will include the following data:

(1) Type and amount.

(2) Lot number.

(3) Date discovered.

(4) Detailed information regarding the nature of the leak, and whether it appeared to have been caused by defective material or improper handling or packing.

(5) Disposition, or in the event that immediate disposition is not required, recommendations for such disposition.

c. A copy of this report will be forwarded direct to the Chief, Chemical Warfare Service.

249. Report of injuries.—Injury reports in duplicate prepared in accordance with existing regulations will be forwarded promptly to the Chief of Ordnance, who will forward one copy to the Chief, Chemical Warfare Service.

250. Special equipment.—*a.* The extreme danger involved in working with chemical ammunition cannot be overemphasized. Because of this danger all personnel who work in magazines or buildings assigned to chemical storage will be provided with appropriate protective equipment. Refer to paragraphs 257, 265, 273, 281.

b. Where special equipment is placed as called for in the following sections of this manual (under the special rules for the storage of various groups of chemical ammunition), a list shall be posted showing the quantity of each item required. This special equipment shall be replenished as required to maintain the full quantity in serviceable condition.

c. All required special equipment will be so marked as to preclude possible misapplication.

d. Special equipment will be inspected to note condition and compliance with rules at each regular inspection of the magazines for which the equipment is provided.

251. Protection of personnel.—*a.* Protective and first-aid equipment will be provided for those employees handling defective or leaky chemical ammunition. For further information on first-aid measures see TM 8-285, Treatment of Casualties from Chemical Agents.

b. Protective equipment which has become unserviceable will be promptly replaced. The officer in charge of each establishment in which protective equipment is on hand will have this equipment inspected as often as is necessary to insure serviceability.

c. Personnel must wash their hands thoroughly with soap and water after handling chemical ammunition and particularly before eating.

252. Signs on magazine doors.—There will be posted on the doors of all magazines containing chemical ammunition appropriate signs such as shown below:

a. Signs for group A chemical ammunition magazines.—"This magazine contains chemical ammunition of group A (blistering agents). Complete protective equipment must be worn to avoid burns, if leaking ammunition is present."

b. Signs for group B chemical ammunition magazines.—"This magazine contains chemical ammunition of group B (toxic and smoke agents). Mask must be worn if odor is present."

c. Signs for group C chemical ammunition magazines.—"This magazine contains group C chemical ammunition (spontaneously inflammable). If fire breaks out, put on asbestos, or heavy leather gloves and place burning component in water."

d. Signs for group D chemical ammunition magazines.—"This magazine contains group D chemical ammunition (incendiary and readily inflammable). Don't use water on fires in this building."

253. Disposition of defective ammunition.—*a.* The methods prescribed for the disposition of defective chemical ammunition in the following sections of this manual, under special rules for each of the several groups, contemplate the destruction of the small number which ordinarily might be encountered.

b. Under exceptional circumstances where large quantities of ammunition are involved the disposition will be, if practicable, by order of the Chief of Ordnance. However, if this delay is not feasible, destruction will be accomplished by methods decided upon by the responsible officer. The methods employed will be predicated on the properties of the fillings as stated herein, but need not follow literally the methods of destruction specified.

254. Packing, marking, and shipping.—Chemical ammunition and components will be packed, marked, and prepared for shipment in accordance with ordnance drawings and specifications for other ammunition. Where applicable, I. C. C. regulations apply to the shipment of chemical ammunition. In brief, these provide that boxes must be marked with the name of content and labeled as prescribed by specific regulations. All containers must be tightly and securely closed. Inside containers must be cushioned. Stowing, loading, and bracing are very important. Packages must be braced so that shifting will not occur. In general, boxes should be stowed on the most stable side and arranged in such a manner that the joints between boxes are staggered. The end of each tier of boxes should be braced with a strong, well-constructed wooden brace well nailed to the floor and the sides of the car or other conveyances, but not to the boxes themselves. Barrels or large drums stow and brace best when standing on their ends. Cylinders and small kegs stow and brace best on their sides.

SECTION XXV

SPECIAL SAFETY REGULATIONS FOR GROUP A CHEMICAL AMMUNITION (PERSISTENT VESICANTS)

255. Description of group A fillings.—*a*. Mustard (CWS symbol, HS; chemical name, bis-beta-chlorethylsulfide) as filled in munitions is a liquid, dark brown to black in color, melting at 46° F. to 50° F.). Its odor is rather faint and somewhat like horseradish or garlic. Its action is that of a vesicant or blistering agent. The liquid, or vapor therefrom, causes intense inflammation which may proceed to blistering of any skin or membrane with which it comes in contact. It causes reddening of the eyes (conjunctivitis), burning of the nose and throat, inflammation of the trachea (windpipe) and lungs, and burning or blistering of the skin. These symptoms develop 4 to 24 hours after exposure, thus giving no warning that a person is being burned. An extremely slight concentration will cause very severe burns. It can be detected by its odor in any concentration likely to produce burns. However, one rapidly becomes accustomed to the odor so that after a few minutes' exposure the smell is no longer noticed. When a dangerous concentration of mustard is detected, it is absolutely essential that all unprotected personnel leave the magazine at once. Any work done thereafter should be performed by men completely protected, wearing gas masks, protective clothing, protective gloves or mittens, and protective shoes or boots.

b. Lewisite (CWS symbol, M-1; chemical name, B-chlorvinyldichlorarsine) like mustard has strong vesicant properties and is a powerful lung irritant. Its vesicant action is not delayed, however, and the blisters differ in appearance from those produced by mustard. Lewisite, being an arsenous compound, has the additional property of entering and poisoning the blood stream. It is classed as a persistent agent, but is readily hydrolyzed by water. However, the hydrolysis product formed is itself a vesicant and very toxic, and contaminated areas will remain dangerous for a long time. Lewisite when pure is a colorless or slightly yellow liquid, but the product as usually prepared is a dark green oily liquid. It has a faint but unpleasant odor which resembles geraniums. The vapor causes a very disagreeable burning sensation in the nose and throat, and sometimes violent sneezing. This material is practically insoluble in water, but is readily soluble in absolute alcohol, benzene, kerosene, olive oil, liquid petrolatum, and other solvents. Woolen clothing gives some protection against M-1 vapor. Wet wool absorbs more than dry wool, hydrolyzing the M-1. Most closely woven rubberized fabrics, as well as leather and rubber, offer little resistance to penetration by liquid M-1. Lewisite is destroyed by an alcoholic solution of caustic soda. Chloride of lime may be used to destroy it in the field. M-1 does not attack steel appreciably, and no special lining is necessary for shells. This material was not used during the World War.

256. Storage.—*a*. Ammunition and components with group A filling will not be stored in magazines with wooden floors. They preferably should be stored in magazines with concrete floors. The floor should be treated with sodium silicate to render it nonabsorbent. The use of rubberoid or other floor covering is prohibited. At all ordnance depots and storage points, ammunition of class A will be stored in fireproof magazines.

b. The slight odor of mustard or lewisite in a magazine may not always indicate the presence of leaking ammunition. However, excessive concentrations of fumes do indicate leaking ammunition. Foremen, inspectors, or other authorized persons who are thoroughly familiar with work in magazines containing these agents must be present when a magazine is opened, in order to determine whether or not the magazine contains leaking ammunition.

c. If it is decided that a magazine contains leaking ammunition all personnel must put on protective clothing and equipment before they enter the magazine. All windows and doors of the magazine will be opened and a search conducted under the direct supervision of some responsible officer or foreman until the leaking ammunition is located.

d. Unboxed ammunition or containers filled with HS (or M-1) must be handled only by personnel wearing protective gloves or mittens.

e. The officer in charge of the storage of munitions in this group will cause frequent inspections to be made to insure compliance with regulations and to ascertain if leaking ammunition is present.

f. Some unboxed shell now in storage are covered with cosmoline. These should not be set on readily combustible material such as wood because, in warm weather, this coating impregnates the wood thereby increasing the fire hazard.

257. Special equipment.—*a.* The following protective equipment will be made available when men are working in magazines where this material is stored:

(1) Service gas masks.

(2) Protective clothing.

(3) Protective footwear.

(4) Protective gloves or mittens.

(5) Commercial bleach or chloride of lime (calcium oxychloride containing not less than 35 percent chlorine (100 pounds for each ton of HS up to a total of 2 barrels of bleach).

(6) Iron tanks of such size as will readily contain the largest shell or container in storage, preferably equipped with handles (55-gallon drum and larger excepted).

(7) First-aid equipment to include: Twenty tubes Protective Ointment M1; 3 dozen clean flannel, or cotton cloths, 1 sq. ft., or equivalent; 1 pint of a solution consisting of 10% sodium

hydroxide, 30% glycerin and 60% water, to be labeled, "FOR REMOVAL OF LEWISITE—EXTERNAL USE ONLY. DO NOT USE IN EYES."; one syringe, or douche cup; 1 nose cup; a supply of soap and water.

b. One percent sodium bicarbonate solution, and saturated boric acid solution will freeze, so it may be impracticable to store them as solutions during the winter months. In this case the requisite amount of sodium bicarbonate or boric acid should be kept in a 1-pint bottle or jar; labeled and corked. To use, fill with water and shake thoroughly, after which it may be applied as directed in paragraph 258 of this section.

258. First aid.—All agents classed as "vesicants" have also a powerful lung irritant action.

a. Mustard gas.—(1) The casualty immediately should be taken out of the contaminated atmosphere or area and his contaminated clothing removed. Any portions of the clothing splashed with liquid mustard should be cut away. If the face has been exposed, wash the eyes and rinse the nose and throat with a saturated boric acid, weak sodium bicarbonate, or common salt solution. If the vapor has been breathed, he should be treated and handled as a lung irritant casualty. (Also see par. 260*a*.) First aid must be prompt, for little can be done later than 20 to 30 minutes after exposure.

(2) Vapor burns on the skin may be mitigated or even prevented by thorough cleansing with soap and water (preferably hot) immediately after exposure.

(3) Mustard burns or skin areas wet with liquid mustard should be immediately and repeatedly swabbed with Protective Ointment M1. The ointment should be thoroughly wiped off after each application.

(4) Fresh cloths should be used and the spreading of contamination should be avoided. After cleansing with the ointment, affected parts should be washed thoroughly with soap and water. Cloths used in removing liquid mustard become contaminated and should be burned or buried after use. A weak, freshly prepared solution of chloride of lime and water may be used if protective ointment is not available. This mixture is itself very irritating to the skin and must, therefore, be removed by subsequent washing with soap and water.

(5) Fresh, uncontaminated clothing must be supplied where necessary. All casualties should be evacuated as soon as possible.

b. Lewisite.—(1) To be of any value against Lewisite, first-aid measures must be instituted very soon after exposure. The treatment is similar to that for mustard.

(2) With Lewisite burns, whether from vapor or liquid, the danger of poisoning from absorbed arsenic far overshadows the effect of the actual burn. Therefore, it is imperative to neutralize, if possible, any arsenic present and not yet absorbed. This may be accomplished by the immediate application of some hydrolyzing agent. The solution of sodium hydroxide (caustic soda) in glycerin has been found very efficient if applied soon enough. Following the hydroxide solution, soap and water should be used.

(3) Fresh, uncontaminated clothing must be supplied where necessary. All casualties should be evacuated as soon as possible.

259. Leaking ammunition.—*a.* When leaking ammunition or components are located they will be disposed of at the direction of the officer in charge.

b. At all times during the handling or disposal of leaking ammunition adequate protective clothing and equipment will be worn by each person so engaged.

c. A leaking shell or component will be immersed in freshly prepared bleach solution and then removed down wind from the magazine area. The bleach solution should be prepared in iron tanks large enough to contain the shell in question. The solution is made up with 3 pounds of chloride of lime to each gallon of water thoroughly mixed.

d. Depending on the facilities available, the final disposal of leaking shell or components should be made by one of the following methods:

(1) In situations where such shell can be dropped into deep ocean water, this is the preferred method of disposal. (See instructions regarding consulting port authorities in par. 65*p*). Where disposal at sea is impracticable, and a sufficiently isolated area is available, the shell should be exploded by static firing. The point where the shell is exploded should be chosen so that personnel can be excluded for a period of approximately 48 hours from the area 1 mile downwind from where the shell is exploded. Also personnel must be prevented from passing within a distance of 150 yards from the point where the shell is exploded, for a period of about 2 weeks.

(2) Where conditions do not permit of using either one of the two methods above outlined, it is suggested that a small hole (about one-fourth inch) be drilled into the void space of the shell. A handful of waste or cloth wadding saturated with 5 percent bleaching powder solution should be held around the point where the shell is being drilled, to absorb any HS vapor emitted when the drill pierces the shell. The hole is then reamed or drilled to a diameter large enough to allow the HS content of the shell to be poured out. The contents of the shell are poured onto a pile of loose earth and bleaching powder mixture in the bottom of a hole about 5 feet deep, dug at least 200 yards from well sites. The pile of loose earth and bleaching powder mixture in the bottom of the hole should consist of an intimate mixture of about 1 bushel of loose earth and 1 bushel of ordinary bleaching powder (35 percent available chlorine). The emptied shell should be placed on top of the bleaching powder, and the hole back-filled to within a foot or so of the top. Then, approximately a barrel of water should be poured into the hole, and the back-filling completed. If HTH (bleaching powder containing about 65 percent available chlorine) is used instead of ordinary bleaching powder in this method of disposal, only about half as much powder should be used. The quantities herein indicated are based on 155-mm. shell which contain approximately 11 pounds of mustard. In the case of 75-mm. shell which contain approximately a pound of mustard, a correspondingly smaller amount of soil and bleaching powder mixture should suffice to destroy the mustard.

(3) The mustard in a shell opened by drilling as above indicated also may be destroyed by pouring it onto a closely packed pile of wood containing about a fourth of a cord. The mustard should be poured uniformly over the wood and the empty shell placed on top of the pile. The wood is then set on fire and personnel excluded from the downwind area to a distance of 200 yards while the wood is being consumed. If the shell is heated to a red heat in this method of disposal mustard adhering to the shell walls will be destroyed. If the shell contains a burster charge, the charge should be removed before the shell is placed on the pile of wood. In emptying the shell, either into soil or onto wood, personnel should remain to windward. Drilling tools contaminated with mustard should be cleaned thoroughly by immersing in a 5 percent solution of bleaching powder for

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10 to 15 minutes and then washing with water. The drilling and emptying of the shell should be done by personnel having a fair knowledge of the properties of HS. They should be aware of the necessity of guarding themselves against contamination either by the vapors or liquid mustard. Masks and protective clothing should be worn in handling leaky mustard-filled shell.

(4) A single leaking shell or component may be exploded in a pit at least 6 feet deep. Place the shell at the bottom of the pit after inserting the bursting charge designed for use with the shell. Connect an electric detonator or blasting cap and fuze to the bursting charge in such a manner as will insure explosion of the charge. Backfill the pit and explode the shell after all personnel have retired to a safe distance. Pour 5 gallons of freshly prepared bleach solution on the fill and then scatter sufficient dry bleach over the fill to cover the disturbed ground to a depth of approximately 2 inches. Place a permanent sign on the fill prohibiting digging in the vicinity.

260. Leaking containers.—*a.* The officer in charge of the magazine, or other responsible officer, will be notified whenever a shipping container is discovered to be leaking. He will take direct personal charge of removal.

b. In general, shipping containers are too large to immerse and handle like a leaking shell. Therefore, an attempt should be made to stop the leak by one or more of the following methods, or by other methods suggested by the nature of the leak.

(1) Place the container so that the leak is at the highest relative elevation.

(2) Calk the leak after wiping with a cloth saturated with bleach solution.

(3) Plaster a lump of moist clay over the leak and bind in place with strips of cloth.

c. After the leak is stopped effectively enough so that the container is satisfactory for further storage, the container will be cleaned thoroughly by the method described in paragraph 261.

d. If leakage has been checked but the container is unsatisfactory for further storage, it should be removed from the building, observing care to prevent reopening the leak. The container should be placed in the most suitable place, and that portion of the container adjacent to the leak should be kept wet with bleach solution pending final disposal of the container.

In the case of containers having dished ends, this may be done by flooding, or in other cases by covering with cloths saturated with fresh bleach solution. The "wick" effect of a soft cotton cloth over the side of a bucket filled with bleach solution may serve to keep the cloth wet.

e. The Chief of Ordnance will be notified of the facts in the case and instructions requested.

f. Leaking containers will be disposed of, in general, by transferring the contents to a serviceable container. The transfer of contents will be done only by specially trained depot personnel after authorization from the Chief of Ordance, or when in the opinion of the commanding officer of the depot immediate action is required. A leak which cannot be stopped should be considered as requiring immediate transfer of the contents of the container.

261. Removal of spilled mustard.—*a.* If mustard from a leaking shell or container has contaminated the floor or other containers, it should be removed by washing thoroughly with freshly prepared bleach solution. If woodwork is stained, it should be removed and burned, as no simple treatment will remove mustard from wood.

b. After washing metal containers, shell, or concrete floor, with bleach solution, dry bleach should be applied and allowed to remain for several days, after which it should be swept up and daily applications of alcoholic caustic made over a period of 2 weeks. If it is impracticable to use alcoholic caustic, freshly prepared bleach solution may be substituted.

c. Alcoholic caustic should not be used without consideration of possible later danger from the contact of loose high explosives with caustic, which undoubtedly will remain in the floor. There is also a possibility of the alcohol being ignited, although this has never yet occurred.

d. The doors and windows of the magazine should remain open until the odor of mustard has disappeared. Complete protective equipment must be worn while conducting any of this work and at all times thereafter until the mustard and its odor have been removed completely from the magazine.

e. In the event that the above-described treatment does not remove all mustard from the floor, the treatment must be repeated. If repetition does not suffice, the only course available is to remove the contaminated portion of the floor and replace with new material. Protective clothing must be worn during such removal. Further details regarding the destruction of HS may be found in applicable field manuals.

262. **Fire in HS magazine.**—*a.* If a fire involves, or threatens buildings in which mustard is stored, all persons within the danger zone will be notified by the commanding officer to vacate until all danger is passed. Members of the fire department, and all others fighting the fire, who may be exposed to mustard, will wear complete protective equipment.

b. Since a fire involving chemical ammunition is most dangerous to inhabitants of the vicinity, special precautions must be taken to prevent fires in areas where this ammunition is stored.

SECTION XXVI

SPECIAL SAFETY REGULATIONS FOR GROUP B CHEMICAL AMMUNITION (TOXICS, IRRITANTS, AND SMOKE)

263. **Description of group B fillings.**—*a. Phosgene* (CWS symbol, CG).—(1) Phosgene is normally a colorless liquid. It boils at 47° F. and has an odor resembling ensilage, or fresh-cut hay. On inhalation, it causes pulmonary oedema or an accumulation of water in the lungs as a result of the irritant action of the chemical. The first symptoms noted in a strong concentration are a choking sensation and a feeling of constriction of the chest. However, the danger lies in the fact that low concentrations that are not particularly irritating may, after an interval of hours, produce serious symptoms, and even death. Among these symptoms are difficulty in breathing, rapid pulse, weakness, coughing with watery expectoration, and cyanosis (a blue color of the skin), caused by inability of lungs to oxygenate the blood.

(2) The delayed action of phosgene makes it imperative that masks be worn whenever the odor is present. Further, because

of its extremely rapid action in high concentrations, gas masks always will be readily available while working with shell or containers filled with phosgene.

(3) In case this material is spilled it will, if left alone, quickly and completely evaporate. Evaporation can be hastened by sprinkling with water. Gas masks must be worn at all times while handling any spilled phosgene. Due to its low boiling point, phosgene in closed containers or shell maintains a high pressure which may be of the order of 160 pounds per square inch under certain conditions.

(4) In case of leakage evaporation will rapidly reduce the temperature to the boiling point, permitting transfer as a liquid. When poured into a warm container, violent boiling will occur until the temperature of the container approaches the boiling point.

b. Chlorpicrin (CWS symbol, PS).—(1) Chlorpicrin is a colorless liquid boiling at 234° F. It has a sweet odor like sticky fly paper and causes irritation of the eyes with lachrymation and some irritation of the nose and throat. Its action is that of a lachrymator and suffocant. In a strong concentration it is nauseating. The first effects are followed by pains in the chest, abdominal discomfort, and vomiting. The principal action, however, is on the lungs, causing suffocation due to water that accumulates in the lungs (pulmonary oedema). Prolonged exposure to very low concentrations may cause serious symptoms. Pulmonary oedema does not develop until several hours after exposure to the gas.

(2) The delayed effect of this agent necessitates the same availability of masks as prescribed for phosgene. A distinct odor and irritation of the eyes is noticed readily in any concentration which would be dangerous.

(3) Chlorpicrin can be removed only with great difficulty, especially from woodwork. The most effective treatment is by means of scrubbing with a liberal application of alcoholic sodium sulphite solution.

(4) Liquid chlorpicrin has a moderate corrosive action on any skin or membrane with which it comes in contact. Care should be observed to avoid contact. If this agent is spilled on the skin, the affected part should be washed repeatedly with soap and water, and treated as soon as possible with alcoholic sodium sulphite.

c. Chlorpicrin and stannic chloride mixture (CWS symbol, NC) is a liquid mixture of chlorpicrin and stannic chloride. Its odor is that of chlorpicrin, and in addition it may be detected by the fumes or smoke produced when it is exposed to air. It should be treated the same as chlorpicrin. As this mixture is slightly corrosive to the skin, contact should be avoided.

d. Stannic chloride (CWS symbol, KJ) is a colorless liquid of suffocating odor. It can be detected by smoke produced on contact with the air or moisture. It should be treated the same as chlorpicrin, inasmuch as its effect on the lungs is similar, although somewhat less marked.

e. Brombenzylcyanide (CWS symbol, CA).—(1) This is a liquid, dark brown in color, which causes intense irritation of the eyes, followed by a prompt flow of tears. Lachrymation does not produce any permanent damage to the eyes, and this chemical has apparently no other effect on the system. Comfort of the worker will require wearing of the mask when in any concentration of this material.

(2) This material is extremely difficult to remove from any surface which absorbs it. The liberal use of alcoholic caustic soda solution tends to reduce the nuisance caused by the presence of this lachrymatory material in a magazine. It should be noted that under many conditions the use of caustic soda in a magazine will be impossible because of the possible effect of the caustic on high explosives which might later be stored in this magazine, or on the bursting charge of chemical munitions. The magazine officer should direct the use of alcoholic caustic in a magazine only after considering this point. Physical contact with the liquid or highly concentrated vapors should be avoided.

f. Diphenylchlorarsine (CWS symbol, DA).—(1) This substance is a solid varying in color from white to black which melts at 111° F. The crude material may be liquid in some cases. Its properties and action are the same as those described under Adamsite (DM), in subparagraph *g* below.

g. Adamsite (*diphenylaminechlorarsine*) (CWS symbol, DM).—DM is a greenish-yellow to black solid melting at 383° F. It causes irritation in the nose and throat even in minute concentrations. Longer exposure causes tightness of the chest, sneezing, headache, coughing, intense nausea, and weakness. The symptoms increase in severity some time after exposure. The irritation produced by the smoke of this agent while burning is so intense that an intolerable concentration is reached long

before it becomes dangerous to life. The effects may last for several hours, but no permanent injury is caused. If any of this material is spilled, it is essential not to sweep it, or handle it in any way to cause dust formation. The material should be wet thoroughly before sweeping up with a broom.

h. Titanium tetrachloride (CWS symbol, FM).—(1) Titanium tetrachloride is a heavy, colorless liquid with a pungent odor. It can be readily detected by the large quantity of smoke produced when it leaks. It is used solely as a smoke-producing agent and has practically no toxic effects. Large quantities of the smoke produce a choking sensation and difficulty in breathing, requiring a gas mask for the comfort of the worker. It can be removed easily by the application of large quantities of water.

(2) In extremely heavy concentrations, canisters of gas masks may become clogged to such an extent as to render breathing difficult. If this occurs the mask should be changed for one in serviceable condition.

i. Chloracetophenone (CWS symbol, CN).—CN is a white to gray or black solid, melting at 138° F. It is a powerful lacrimator and has a somewhat fruity odor. Usually it is put in candles with smokeless powder to cause it to burn, or filled in liquid form in which CN is dissolved in suitable solvents. In solution, the odor of the solvent is usually discernible in addition to that of the chloracetophenone itself. In any case it is a strong lacrimator but does not cause permanent damage to the eyes. Its lachrymatory effects require the use of masks for the comfort of workers. It can be removed best by scrubbing with soap and water, followed by liberal applications of alcoholic sulphite solution, or by the use of the sulphite solution alone. Actual contact with pure solid material, or high concentrations of the material in the air produces a burning sensation on the skin. Such contact should be avoided.

j. Chlorine (CWS symbol, Cl).—(1) Chlorine is a greenish-yellow liquid or gas boiling at −30° F. It has a pungent odor. The first effects produced by inhalation of small proportions of chlorine is an active irritation of the upper respiratory passages, causing coughing and a sensation of suffocation which is exceedingly disagreeable. The odor of chlorine is very strong in any concentration that would cause irritation or symptoms of poisoning. When present in amount strong enough to cause irritation, masks should be worn and all personnel not so equipped should leave the vicinity. In case of leaking chlorine, dangerous quantities should be removed by ventilation.

(2) Like phosgene, only to a greater extent, chlorine generates pressure when sealed in containers. The pressure may be 200 pounds per square inch under field conditions.

k. Sulphur trioxide-chlorsulfonic acid mixture (CWS symbol, FS) is a heavy mixture which fumes strongly in air, and decomposes above 68° C. (154° F.). It has an acid odor. It is used solely as a smoke-producing agent, and there is no evidence that it is harmful to man in concentrations normally attained in the field. Inhalation of concentrated fumes causes coughing and strangulation; a feeling of constriction around the chest, burning of the nose and throat, and hoarseness. When the mixture comes in contact with moisture, it forms hydrochloric acid and sulfonic acid, thus making it very corrosive to metals and to fabrics of various kinds. If applied directly to the skin, a burning sensation is felt at once and an acid burn follows. FS mixture on the skin, or clothing should be wiped off thoroughly with a dry cloth or waste, then flushed off with large amounts of water. FS mixture is noninflammable.

l. Chloracetophenone-chloroform-chlorpicrin (CWS symbol, CNS) is a solution of chloracetophenone (CN), chlorpicrin (PS) and, chloroform. Its odor is somewhat like that of sticky fly paper. In strong solution it may cause nausea in addition to severe lachrymation. An individual exposed to extremely high concentrations for a relatively short time may suffer serious effects such as pains in the chest, abdominal discomfort, vomiting, and an action upon the upper air passages and bronchial tubes somewhat similar to, but less than that of chlorine. Prolonged exposure, even to a very low concentration, may cause these effects. CNS has only a slight action on metals.

m. Chloracetophenone-benzol-carbon tetrachloride (CWS symbol, CNB) is a solution of chloracetophenone (CN) in benzene and carbon tetrachloride. This solution should not be permitted to come in contact with the skin or eyes because of the considerable discomfort and possible injury that may result. It has no appreciable action on metals.

264. Storage.—*a.* Ammunition and components with group B filling will not be stored in magazines with wooden floors. Preferably, they should be stored in magazines with concrete floors. The floor should be treated with sodium silicate to render it nonabsorbent. The use of rubberoid, or other floor covering is

prohibited. At all Ordnance depots and storage points, munitions of group B will be stored in fireproof magazines.

b. Whenever a magazine containing group B chemical munitions is opened a foreman or other responsible persons familiar with work in magazines containing this material must be present to determine whether munitions in the magazine are leaking. If it is decided that munitions in the magazine are leaking, masks will be worn and the doors and windows opened after which the leaking shell or container should be located.

c. Masks should be readily available to all men working in these magazines. Unboxed shell and containers may be handled without protective gloves unless contamination is noted. However, in some cases, a small amount of filling may be left on the outside of a shell during the filling of group B munitions. Protective gloves or mittens should be worn when handling contaminated material.

265. Special equipment.—The following protective equipment will be made available when men are working in magazines where this material is stored:

a. Service gas masks.

b. Protective gloves or mittens.

c. Stretchers or litters.

d. Woolen blankets.

e. Eight ounces of a mixture consisting of 4 ounces pure grain alcohol (95 percent), and 4 ounces chloroform, United States Pharmacopoeia, to which is added a few drops of ammonia.

f. One carboy of a saturated solution of sodium sulphite in pure grain alcohol (95 percent). This carboy must be kept sealed to prevent evaporation. This solution is for use in treating burns on the skin from liquid chlorpicrin and cloracetophenone as described in paragraph 263*b*(4) and 263*l*.

g. One carboy of a saturated solution of sodium hydroxide (caustic soda) in pure grain alcohol (95 percent). This carboy must be kept sealed to prevent evaporation. This solution is for use in removing brombenzylcyanide, as described in paragraph 263*c*(2). This solution will not be used on personnel under any circumstances.

266. First aid.—*a. Pulmonary irritants.*—The first-aid treatment of pulmonary irritants, including phosgene, chlorpicrin, stannic chloride, and chlorine is the same. Absolute rest and warmth are essential. The patient should be removed immediately to a pure atmosphere and made to lie down, kept at absolute rest, and kept warm with blankets. A person affected by pulmonary irritants always should be moved on a litter or stretcher. He must never be allowed to walk. A light stimulant or hot coffee may be given. A glass of milk or cream, if available, will give marked relief from pharyngeal irritation, and the patient should be hospitalized. In cases of splashes of liquid on the skin, wash it off at once with alcoholic sodium sulphite, in order to prevent ulcerations. Skin scratches and abrasions exposed to chlorpicrin fumes or liquid develop a high degree of inflammation and easily become infected.

b. Lacrimators.—Lacrimation produced by brombenzylcyanide, chlorpicrin, and chloracetophenone produces no permanent damage. Removal of the patient to a pure atmosphere will be a sufficient treatment in most cases. In more aggravated cases, or those exposed to a strong concentration of the gas, washing the eyes with a saturated solution of boric acid will be beneficial. Do not rub the eyes or bandage them. Where there is a skin rash, wash with alcoholic sodium bicarbonate solution (made by dissolving 100 grams of sodium bicarbonate in 500 cubic centimeters of water and then adding 500 cubic centimeters of ethyl alcohol.) This solution must be shaken before using because the addition of alcohol causes some of the bicarbonate to be precipitated.

c. Irritant smokes.—The irritant smokes, diphenylchlorarsine and Adamsite will not cause permanent injury. Remove the patient from the contaminated atmosphere and away from heat. Flush the nose with salt water or bicarbonate of soda solution. Remove all outer clothing and wash the surface of the body, including the scalp, with soap and water. Allow this solution to dry upon the skin and then dust the skin with borated talcum. Let the patient breathe weak chlorine atmosphere for 10 minutes from a handful of dry bleach powder in a wide-mouth bottle, or can. If patient is delirious, he must be watched or restrained to prevent self-injury.

d. Smoke.—FM or FS will not, as a rule, produce any effects requiring treatment. If a person has been subjected to a very strong concentration of smoke without the protection of a mask, he should retire to fresh air until recovered.

267. Leaking ammunition.—*a.* When leaking ammunition or components are located, they must be disposed of at the direction of the officer in charge.

b. A gas mask and protective gloves will be worn whenever handling leaking ammunition filled with group B material. Care should be observed that the leaking material does not come in contact with skin or clothing.

c. Pending final disposal, leaking ammunition will be removed from the magazine.

d. If the number of leaking shell or components is small, they should be destroyed as described below:

(1) The preferred method is to sink the complete shell or component in deep ocean water. (See instructions regarding consulting part authorized in par. 65*p*).

(2) A single leaking HS shell may be exploded by static firing. The point at which the shell is exploded should be chosen so that personnel can be excluded for a distance of about 500 yards for a period of about 48 hours. A small hole about 2 feet deep, with vertical sides, should be dug. The shell is placed at the bottom of the pit in a horizontal position with TNT blocks placed on the outside of the shell, directly over the bursting charge. Electric detonators will be used to explode the TNT after all personnel have retired to a safe distance. The ground around the exploded shell should be thoroughly decontaminated by scattering a mixture of bleach powder and sand over it. The hole should be filled with a mixture of dry bleach powder and earth. A sign should be placed upon the fill prohibiting digging in that vicinity.

e. If a large number of shells are involved, the magazine should be ventilated, placed under guard, and the Chief of Ordnance notified by telephone or telegraph. (See also sec. XXIV, par. 253*b*.)

268. Leaking containers.—*a.* The officer in charge of the magazine will be notified whenever a shipping container is discovered to be leaking. He will inspect personally the container involved to determine proper disposition.

b. As soon as possible after discovery of a leaking container, and pending arrangements for its removal, attempt should be made to place the container in a position to prevent the contents from spilling on the floor or on other containers. If possible, this should be done by the man discovering the leak.

c. If the leak is stopped easily without allowing a large quantity of the filler to escape, the container may remain in the magazine. If the leak is not stopped promptly, the container must be transported down wind from the magazine area.

d. Containers in which the leaks have been stopped in such manner as, in the opinion of the magazine officer, renders them serviceable for continued storage, may remain in the magazine. Containers which cannot be repaired satisfactorily with the facilities at hand will have the contents transferred to serviceable containers under the direct supervision of the magazine officer.

e. The method of transferring contents will vary with existing conditions and the nature of the material. The method adopted must be predicated on the properties of the material as described in paragraph 263 of this section.

269. Removal of spilled material.—*a.* In case materials of group B have leaked from shell or containers and contaminated the floor or other containers, the treatment to be used will be as outlined in paragraph 263 of this section under the description of the material involved.

b. Gas masks and protective gloves must be worn while removing group B chemical fillings which have been spilled.

270. Fire in magazines.—*a.* The same precautions will be observed for fires in areas containing group B chemical ammunition as were outlined under paragraph 262 for fires in HS magazines except that the danger to personnel down wind from the fire is less in the case of group B ammunition than in the case of a fire involving HS.

b. Any shell or container which has been exposed to fire should be considered dangerous and made the subject of special inspection to ascertain its condition. A report should be made to the Chief of Ordnance and instructions requested.

Section XXVII

SPECIAL SAFETY REGULATIONS FOR GROUP C CHEMICAL AMMUNITION (SPONTANEOUSLY INFLAMMABLE)

271. Description of white phosphorus.—*White phosphorus* (CWS symbol, WP) is a yellowish, translucent, wax-like substance, melting at 111° F. Its most characteristic property is that of spontaneously igniting upon exposure to air, burning with an intensely hot flame, and giving off large volumes of white smoke. The fumes are not toxic except on exposure for a period of several months. Phosphorus is intensely poisonous when taken internally. Precautions should be taken to insure that none is introduced into the body.

272. Storage.—*a.* Chemical ammunition containing group C fillings must be stored in fireproof magazines with concrete floors. The preferred storage is in igloo magazines. It will be stored in accordance with current Ordnance drawings, where applicable, except for those lots for which special instructions are issued by the Chief of Ordnance. In any case, ammunition containing white phosphorus will be stored in such a manner as to permit easy inspection.

b. The white phosphorus filling in ammunition or components becomes liquid at 111° F. At or above this temperature, defective ammunition may leak, and may catch fire, and in some cases (where a burster was in place) has been known to explode. Below 111° F., the filling is solid, and shell will not leak. It is highly important, especially where this ammunition is stored on its side, that the temperature at which it is stored be kept below 111° F.

273. Special equipment.—There will be maintained at all times adjacent to each magazine in which group C chemical munitions are stored the following special equipment:

a. Heavy rubber gloves (gauntlet type), rubber boots, and ankle-length rubber aprons sufficient in number to equip all personnel required to work in the magazine.

b. A number of tubs, barrels, or tanks large enough to contain the storage unit. During the summer months when fires are most likely in this type of ammunition, these tanks must be kept filled with water. Also, during the summer months, there should be stretched a line of hose of sufficient length to reach any part of the magazine.

c. Two sponges and a pail or other vessel holding approximately 5 gallons.

d. A bathtub or similar container for first aid, and a means of heating water for use therein, will be maintained in some heated building as close as possible to the magazines of this group. Also a small number of gauze sponges will be maintained.

c. One bottle containing at least 1 gallon of 3 percent copper sulphate solution.

274. Leaking ammunition.—*a.* With leaking shell of this group the great risk is that of fire. This can be combated successfully only by prompt action. In general, the time elapsing from the time the fire is reported until the arrival of the fire department is sufficient to allow the fire to get beyond control.

b. A leaking shell or container of any type should be immersed immediately in one of the tubs provided in the magazine. The person discovering the leaking shell should put on rubber gloves and attempt to immerse it at once. In the event that this action is impracticable, the hose should be used with hydrant pressure. This is important, as a low-pressure stream of water will tend to smother the fire, whereas high pressure tends to scatter the fire over a large area, and thus greatly increases the difficulty of extinguishing it.

c. Rubber gloves will give protection against burns only, as they prevent contact of the phosphorus with the skin. Gloves are not effective when exposed to high temperatures, such as burning phosphorus. When burning phosphorus adheres to gloves, it can be extinguished by dipping the gloved hand in water.

d. When a single leaking shell has been discovered and immersed in water, it should be destroyed, as described in paragraph *e* below, at a place where fragmentation will not be a hazard, smoke will not create a nuisance, and there is no dry vegetation which may be ignited.

e. The shell to be exploded should be treated as follows:

(1) When the shell does not contain a fuze or burster, remove to a point where fire risk is negligible and destroy the shell by static firing. All personnel must retire to a safe distance before the shell is exploded.

(2) Where the shell is not in a container, and is fitted with fuze or burster, it will be extinguished, if on fire, before it is handled or moved. This condition is extremely hazardous, and the handling of the shell should be carried out under an officer or foreman, or other employee familiar with chemical ammunition. After the flame has been extinguished the instructions given in (1) above will be followed.

(3) Where the ammunition is packed in a container, and is fitted with either fuze or burster, the fire will be fought with water from outside the magazine. Defective shell will be removed if and when the fire is extinguished. If the leaking shell is removed, subsequent action will be in accord with paragraph (1) above.

f. The charge of demolition blocks to be used for destruction of leaking group O ammunition will be as follows:

Chemical ammunition	Number of demolition blocks	Chemical ammunition	Number of demolition blocks
75-mm. artillery shell	4	8-inch livens projector shell	3
155-mm. artillery shell	5	5-pound aviation bomb	1
8-inch artillery shell	6	25-pound aviation bomb	2
81-mm. mortar shell	2	50-pound aviation bomb	2
4-inch chemical mortar shell	2	100-pound aviation bomb	3
4.2-inch chemical mortar shell	3		

275. Removal of spilled phosphorus.—*a.* Where phosphorus has leaked on the floor or other parts of a magazine and has been extinguished, a fire guard must be stationed within the building until it has been completely removed, as the drying up of the water will permit the phosphorus to ignite again.

b. Small amounts of phosphorus can be removed best by first scraping off as much as possible with an implement such as a putty knife and then removing the rest by burning with a blow torch or similar appliance. This removal of phosphorus must not be attempted until all loaded ammunition in the vicinity has been removed.

c. After treatment, as above described, the magazine will be kept under surveillance for at least 2 weeks, as fire may break out again. Portions of the floor containing deep cracks or crevices will be grouted with mortar before munitions are restored in the magazine.

276. Fire in magazines.—In the event of a fire in a magazine containing ammunition fitted with fuze or booster, and packed in containers, if the fire cannot be controlled, the magazine will be abandoned, and fire-fighting efforts confined to saving adjacent magazine. In cases of fires involving other group C chemical ammunition. If the fire gets beyond the control of the person discovering it, the following precautions not generally necessary during ordinary fires, must be observed in order to attack the flames successfully.

a. Phosphorus once extinguished must either be immersed under water or continually sprayed to prevent the flames breaking out anew.

b. Due to the great amount of smoke liberated, there is an extra hazard of men becoming lost in the magazine while attempting to fight the flames. Men with portable extinguishers should not be permitted in the magazine after a fire gains headway unless they are equipped with lifelines, as they would have no hose line to follow back in order to escape from the magazine.

c. Components becoming highly heated in a fire will explode with moderate violence, throwing burning containers for some distance. This tends to spread the fire rapidly.

d. As a high velocity stream of water tends to spread the fire, the lowest pressure stream consistent with possibility of approach should be used.

e. After a fire has been extinguished in a magazine, all adjacent shell and components will be considered dangerous and a report of the fire will be made immediately to the Chief of Ordnance.

f. The opening of fiber containers to inspect ammunition containing white phosphorus will be done outside the building, 100 feet from any building containing explosives or ammunition.

277. Guards at magazines.—There will be maintained at all times a periodic inspection by fire guards, of magazines containing group C munitions. Guards walking post near these magazines will be especially instructed to report immediately any smoke seen issuing from a magazine.

278. First aid.—*a*. The most likely injuries from phosphorus in storage are burns. Burns from phosphorus are especially severe because the phosphorus keeps on burning even when buried in the flesh.

b. The part affected by a phosphorus burn should be plunged under water as soon as possible. This will stop the phosphorus from burning. Then apply large amounts of copper sulphate (3 percent) solution. Continue this treatment for 3 minutes. Remove the phosphorus particles (copper-plated) by washing or with forceps and treat the injury like an ordinary burn.

SECTION XXVIII

SPECIAL SAFETY REGULATIONS FOR GROUP D CHEMICAL AMMUNITION (INCENDIARY AND READILY INFLAMMABLE)

279. Description of group D fillings.—*a*. *Thermit* (CWS symbol, TH) is a mixture of iron oxide and aluminum. It is in the form of a dark-gray granular mass. When ignited it burns with great rapidity and the evolution of extreme heat, the iron oxide being reduced to boiling molten iron.

b. *Hexachlorethane mixture* (CWS symbol, HC) consists largely of hexachlorethane and zinc. It is a gray solid with a camphorlike odor. It burns rather slowly with the evolution of a dense cloud of smoke. The smoke produced is harmless and can be breathed without discomfort.

c. *Incendiary bombs*.—Incendiary bombs comprise a combustible body of magnesium metal, inside of which is an igniter composition such as thermit. When ignited, the body of the bomb burns with intense heat.

d. *Chloracetophenone burning mixture* (CWS symbol, CN) is a mixture of CN and small grain smokeless powder. It is employed in hand and rifle grenades. It is most effective when distilled into the air by the heat of a burning composition.

e. *Diphenylaminechlorarsine burning mixture* (CWS symbol, DM) is a mixture of DM and smokeless powder. Like CN, diphenylaminechlorarsine is most effective when disseminated as a smoke.

f. *Burning mixture CN–DM* (CWS symbol, CN–DM) is a mixture of chloracetophenone and diphenylaminechlorarsine with smokeless powder.

280. Storage.—*a*. Chemical munitions containing fillings of group D may be stored in any dry, fireproof magazine.

b. Inspection and guard of ammunition of this type will be the same as that maintained for high-explosive shell.

281. Special equipment.—Unboxed ammunition containing roup D material may be handled without special protective quipment. Some suitable equipment for fighting oil fires will e maintained at all times adjacent to magazines in which mateal of this class is stored.

282. Leaking ammunition.—*a.* In the event that containers r shell containing group D materials are discovered in a leakg condition they should be segregated. Instructions as to the isposition of such shell will be requested from the Chief of rdnance.

b. Leaking munitions of this group will be destroyed if necesry by burning, in the same manner as intended for service use, t in the case of bombs, statically, in an area where fire risk negligible.

283. Removal of spilled material.—In the event that comments are broken open or leaking, the material should be vept up, removed from the building, and burned.

284. Fire in magazines.—*a.* The efforts of fire fighters ould be confined to preventing the spread of the fire. Fire in magazine containing hexachlorethane mixtures or magnesium ould not be fought with water.

b. Unburned material in a magazine which has been parlly destroyed by fire should be treated with the greatest caun, as HC mixture may absorb sufficient moisture to cause nition with subsequent recurrence of the fire.

285. First aid.—No unusual first-aid treatment is required r accidents occurring in handling this type of material. Burns ll be treated in the same manner as any other burn.

APPENDIX II

Storage chart for Explosives and Ammunition

The letter X at an intersection of a horizontal and vertical column shows that the item in the horizontal column may be stored with the item in the vertical column	Adapters & boosters	Aluminum powder	Ammonium nitrate	Black powder, charges or containers	Blank ammunition for cannon	Bombs, demolition	Bombs, fragmentation (metal crates)	Bombs, fragmentation (wood crates)	Bombs, photoflash	Bombs, practice, packed with spotting charge	Chemical ammunition, Group A	" " B	" " C	" " D	Chlorates, perchlorates & peroxides	Cyclonite	Demolition blocks	Detonators, blasting & percussion caps	D.N.T.	Dynamite	Explosive D	Flashlight powder	Fuzes, anti-tank mine	Fuzes, time & detonating	Grenades, fragmentation & practice	Grenade fuzes	Lead azide (wet)	Light mortar shell (81mm and less)	Magnesium powder	Mercury fulminate (wet)	Mines, anti-tank, H.E.	Mines, anti-tank, practice	Nitrocellulose	P.E.T.N. (wet)	Picric acid	Primers & primer detonators	Pyrotechnics	Shell H.E. for separate loading & fixed ammu.	Shell & shrapnel fixed & semifixed	Shrapnel, separate loading	Small-arms ammunition	Smokeless powder, charges or containers	Spotting & smoke-puff charges	Tetryl	Tracer mixture	TNT in bulk
Adapters & Boosters	X																	X					X	X		X										X					X					
Aluminum powder		X																											X																	
Ammonium nitrate			X																X																											
Black powder, charges or containers				X																																							X			
Blank ammunition for Cannon					X			X		X															X			X				X							X	X	X					
Bombs, demolition						X	X																																							
Bombs, fragmentation (metal crates)						X	X																																							
Bombs, fragmentation (wood crates)					X			X		X															X			X				X							X	X	X					
Bombs, photoflash									X																																					
Bombs, practice, packed with spotting charge					X			X		X															X			X				X							X	X	X					
Chemical ammunition, Group A											X																																			
" " " B												X																																		
" " " C													X																																	
" " " D														X																																
Chlorates, perchlorates & peroxides															X																															
Cyclonite																X																												X		
Demolition blocks																	X				X														X											X
Detonators, blasting & percussion caps	X																	X					X	X		X										X					X					
D. N. T.			X																X																											
Dynamite																				X																										
Explosive D																	X				X														X											X
Flashlight powder																						X																								
Fuzes, anti-tank mine	X																	X					X	X		X										X					X					
Fuzes, time & detonating	X																	X					X	X		X										X					X					
Grenades, fragmentation & practice					X			X		X															X			X				X							X	X	X					
Grenade fuzes	X																	X					X	X		X										X					X					
Lead azide (wet)																											X			X				X												
Light mortar shell (81mm and less)					X			X		X															X			X				X							X	X	X					
Magnesium powder		X																											X																	
Mercury fulminate (wet)																											X			X				X												
Mines, anti-tank, H. E.																															X															
Mines, anti-tank practice					X			X		X															X			X				X							X	X	X					
Nitrocellulose																																	X													
P. E. T. N. (Wet)																											X			X				X												
Picric acid																	X				X														X											X
Primers & primer detonators	X																	X					X	X		X										X					X					
Pyrotechnics																																					X				X					
Shell H.E. for separate loading & fixed ammu.																																						X								
Shell & shrapnel fixed & semifixed					X			X		X															X			X				X							X	X	X					
Shrapnel, separate loading					X			X		X															X			X				X							X	X	X					
Small-arms ammunition	X				X			X		X								X					X	X	X	X		X				X				X	X		X	X	X					
Smokeless powder, charges or containers																																										X				
Spotting & smoke-puff charges				X																																							X			
Tetryl																X																												X		
Tracer mixture																																													X	
TNT in bulk																	X				X														X											X

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WAR DEPARTMENT TECHNICAL MANUAL

TM 9-1900

This Technical Manual supersedes TM 9-1900, dated 3 July 1942, and Changes No. 1, dated August 1943; OST 9-18, Vols. 1 to 5, incl., dated October 1942; OFSTB 1900-11, dated 13 January 1943; OFSTB 1900-13, dated 22 April 1943; WDTB 9-1900-13, dated 22 April 1943; OFSTB 1900-16, dated 11 June 1943; OFSTB 1900-17, dated 20 September 1943; WDTB 9-1900-19, dated 5 August 1944; and WDTB ORD 51, dated 5 March 1943. This Technical Manual supersedes portions of WDTB ORD 194 (a reprint of OFSTB 1900-18), dated 6 November 1943; WDTB ORD 214, dated 28 October 1944; and WDTB ORD 249, dated 1 February 1945.

AMMUNITION, GENERAL

WAR DEPARTMENT • 18 JUNE 1945

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WAR DEPARTMENT
Washington 25, D. C., 18 June 1945

TM 9-1900, Ammunition, General, is published for the information and guidance of all concerned.

[A.G. 300.7 (22 Aug 44)
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BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
EDWARD F. WITSELL,
Major General,
Acting The Adjutant General.

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(For explanation of symbols, see FM 21-6.)

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RESTRICTED

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CHAPTER 1
GENERAL

Section I
INTRODUCTION

1. PURPOSE.

a. This manual is published for the information and guidance of Army personnel concerned with ammunition. Those responsible for the handling of ammunition should become thoroughly familiar with its provisions.

b. The requirements of this manual will apply to Class I, II, and III installations. The requirements of the Ordnance Safety Manual (O.O. Form 7224) will govern Class IV installations under the control of the Chief of Ordnance.

2. SCOPE. The information contained in this text is of a general technical nature. It concerns the several types of ammunition, their general characteristics, means of identification, care in handling and use, storage, surveillance, packing and marking, shipping, and the destruction of duds and unserviceable ammunition.

3. REFERENCES. Further information concerning specific types of ammunition is contained in specific Technical Manuals and Field Manuals. A complete list of references appears in chapter 5.

Section II

GENERAL DISCUSSION

4. NOMENCLATURE.

a. **SNL groups.** Standard nomenclature is established so that every item supplied by the Ordnance Department may be specifically identified by name. It consists of the type, size, and model of each item. Its use for all purposes of record is mandatory, except where use of AIC symbol (par. 4 b) is authorized. Ammunition nomenclature is published in ORD 11 Standard Nomenclature Lists (SNL's) of groups P, R, S, and T, and its exact use will keep to a minimum errors in the shipment, storage, issue, recording, and use of ammunition items.

(1) Group P contains lists of ammunition for medium and heavy field artillery (155-mm gun and above), coast artillery, and antiaircraft weapons.

(2) Group R contains lists of ammunition for light and medium field, tank, antitank, and aircraft artillery weapons (20-mm gun through 155-mm howitzer), mortars, mines, and demolition material.

(3) Group S contains lists of bombs, grenades, pyrotechnics, and rockets.

(4) Group T contains lists of ammunition for small-arms weapons.

b. **Ammunition Identification Code symbols.** The Ammunition Identification Code (AIC) symbol has been established to facilitate the supply of ammunition in the field. Code symbols assigned to each item of ammunition in a specific packing are to be used in messages, requisitions, and records. These code symbols are published basically in ORD 11 SNL's of groups P, R, S, and T. A full explanation of the composition and use of the AIC symbol will be found in SB 9-AMM 5 and changes thereto.

5. CLASSIFICATION.

a. **General.** Ammunition is classified according to use as service, practice, blank, or drill (or dummy). It may also be classified according to type of filler as explosive, chemical, or inert.

b. **Service ammunition.** Service ammunition is intended to be fired for effect in combat. Such ammunition (except small-arms ammunition) may be further classified according to type as high-explosive, high-explosive-antitank, armor-piercing, gas, smoke, canister, incendiary, illuminating, or pyrotechnic.

c. **Practice ammunition.** Practice ammunition is fired for effect in simulated combat and is provided for training in marksmanship. The projectile in this type of ammunition may have a small quantity of low-explosive filler to serve as a spotting charge, or it may be inert.

d. **Blank ammunition.** Blank ammunition is provided in small and medium calibers for saluting purposes and simulated fire. It has no projectile.

e. **Drill ammunition.** Drill or dummy ammunition is used for training in handling and loading ("service of the piece"). It is completely inert.

6. IDENTIFICATION.

a. **General.** Ammunition is completely identified, except as to grade, by painting and marking on original packing containers. For purposes of record, the standard nomenclature of the item, together with its lot number, completely identifies the ammunition. Once removed from its packing, ammunition may be identified by the painting and marking on the ammunition items. Other essential information may also be obtained from the marking on ammunition items. The muzzle velocity of projectiles may be obtained from the firing tables and ammunition data cards; in the case of some rounds of smaller caliber, the muzzle velocity may appear on the packing box. Included in both the marking and the standard nomenclature are:

(1) A brief description of the type or suitable abbreviation thereof.

(2) Caliber, weight, or size.

(3) Model designation.

(4) Where required, such additional information as the model and type of fuze, the model of the cannon in which the item is fired, the weight of projectile for which a separate-loading propelling charge is suited, etc.

(5) The lot number is marked on the ammunition but is not a part of the nomenclature. However, when referring to specific ammunition, it is necessary to mention the lot number as well as the standard nomenclature.

b. **Mark or model.** To identify a particular design, a model designation is assigned at the time the model is classified as an adopted type. This model designation becomes an essential part of the nomenclature and is included in the marking of the item. The present system of model designation consists of the letter "M" followed by an arabic numeral, for example, "M1." Modifications are indicated by adding the letter "A" and the appropriate arabic numeral. Thus, "M1A1" indicates the first modification of an item for which the original model designation was "M1." Wherever a "B" suffix appears in a model designation it indicates an item of alternative (or substitute) design, material, or manufacture. Certain items standardized for use by both Army and Navy are designated by "AN" preceding the model designation, for example, AN-M103A1, AN-Mk 19. From World War I to 1 July 1925, it was the practice to assign mark numbers, that is, the word "Mark," abbreviated "Mk," followed

by a roman numeral. The modification was indicated by the addition of MI to the mark number, the second MII, etc.; after 2 April 1945, these roman numerals in Mark numbers will be indicated by arabic, rather than roman, numerals. This change from roman to arabic numerals will affect ammunition items in use by the U. S. Army which are of British or Navy origin, and also older army items which are now assigned Mark numbers. Prior to World War I, the year in which the design was adopted, preceded by the letter "M," was used as the model designation, for example, M1914.

c. **Ammunition lot number.** At the time of manufacture every item of ammunition is assigned a lot number. Where the size of the item permits, it is marked on the item itself to insure permanency of this means of identification. In addition to this lot number, there is assigned to each complete round of fixed and semifixed ammunition an ammunition lot number which serves to identify the conditions under which the round was assembled, and the components used in the assembly. This ammunition lot number is marked on every complete round of fixed and semifixed ammunition (except where the item is too small) and on all packing containers. It is required for all purposes of record, including reports on condition, functioning, and accidents, in which the ammunition is involved. As far as practicable, all complete rounds of any particular ammunition lot are made up of components selected from the same lot. To obtain the greatest accuracy in any firing, successive rounds should be from the same ammunition lot.

d. **Ammunition data card.** Ammunition data cards will be furnished in the prescribed amounts for all ammunition items of issue except small-arms ammunition. This is a 5- by 8-inch card, on which is printed data concerning the item and its components. Data cards are forwarded with shipping tickets at the time of shipment and are also sent to the ultimate consignee. Information on the cards includes lot number; date packed; identity of components; expected pressures; expected muzzle velocity; assembling and firing instructions when required; and AIC symbols on lots now being produced.

7. PAINTING AND MARKING.

a. **Painting.** Ammunition is painted primarily to prevent rust. Secondary purposes are to provide, by the color, a ready means of identification as to type, and to camouflage the ammunition by the use of lusterless olive-drab paint. See figures 1 to 16, inclusive, for the use of color on ammunition and its packings. The color scheme is as follows:

(1) For ammunition other than bombs, small-arms ammunition, and pyrotechnics:

High-explosive	Olive-drab, with marking in yellow
Low-explosive	Red, with marking in black
Illuminating	Gray, with 1 white band and marking in white
Chemical:	
Persistent casualty gas	Gray, with 2 green bands and marking in green
Nonpersistent casualty gas	Gray, with 1 green band and marking in green
Persistent harassing gas	Gray, with 2 red bands and marking in red
Nonpersistent harassing gas	Gray, with 1 red band and marking in red
Smoke	Gray, with 1 yellow band and marking in yellow
Incendiary	Gray, with 1 purple band and marking in purple
Practice	Blue, with marking in white
Dummy or inert	Black, with marking in white (bronze or brass assemblies are unpainted).

(2) For bombs, other than chemical and practice, the painting is olive-drab, and 1-inch color bands are painted at the nose and tail ends of the body. Markings are in black, except for the incendiary bomb which has purple stenciling. The color of the bands is as follows for the types of bombs indicated:

High-explosive	Yellow
Incendiary	Purple
Drill or inert	Black

When bombs are loaded with Composition B, "COMP. B" is stenciled twice, 180 degrees apart on each band. When bombs are loaded with tritonal, a third color band, ½-inch wide, is located midway between the two bands on either end. These bombs have an inert pad in each end. When TNT or COMP. B loaded bombs are equipped with inert pads, they will be stenciled "WITH PADS" to distinguish from bombs with the small filling, but without pads; the purpose of the inert pad is to render the bomb less sensitive to blows on the end during handling and shipping. Practice bombs are painted blue with white markings but have no color bands. Small fragmentation bombs have no color bands but the nose and tail are painted yellow. Chemical bombs are painted gray, except incendiary bombs which are painted olive-drab, and marked with color bands and stenciling in accordance with the color scheme for other ammunition given in step (1), above.

(3) Small-arms cartridges do not require painting. However, the bullet tips of cartridges are painted a distinctive color (fig. 1) to aid in ready identification as to type, as follows:

Ball	No color tip
Armor-piercing	Black
Armor-piercing-incendiary	Aluminum (silver)
Armor-piercing-incendiary-tracer	Red with aluminum annulus to the rear

Incendiary	Various shades of blue
Tracer	Various shades of red, such as orange and maroon, and white
Frangible	White tip with green annulus to the rear

(4) Pyrotechnics are not marked in accordance with the general color scheme but, where color markings are used, they indicate the color of the pyrotechnic effect produced. In general, however, pyrotechnics, are painted gray with marking in black. If the body of the item is aluminum or magnesium, it may not be painted. If the item is intended for incendiary purposes, markings are in purple.

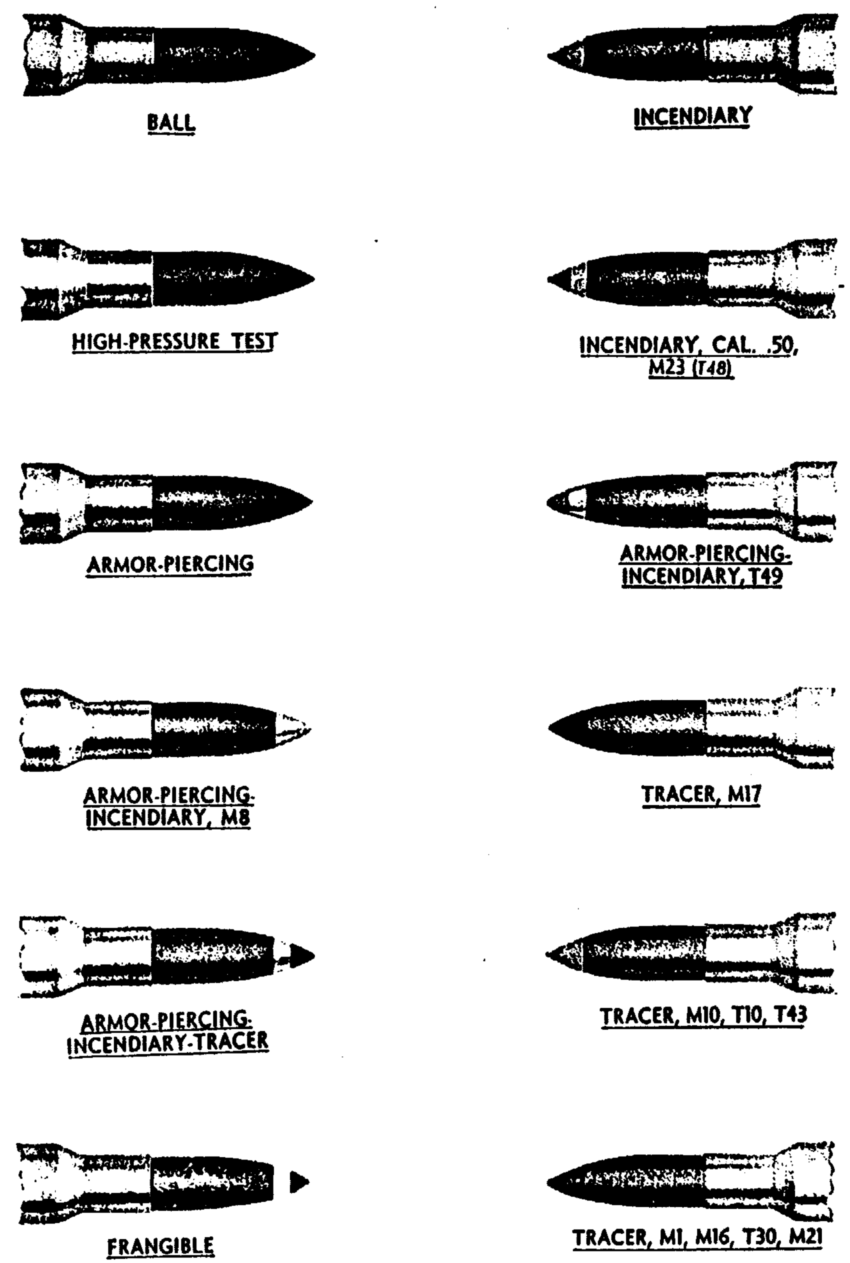
b. **Marking.** The marking stenciled or stamped on the ammunition and on its packing container includes all information necessary for complete identification. Further information concerning painting and marking will be found under the specific type of ammunition in chapter 2 and in section IV of chapter 3.

8. GRADING.

a. Ammunition is manufactured to rigorous specifications and is thoroughly inspected before acceptance. Ammunition in storage is periodically inspected and tested in accordance with specific instructions furnished by the Chief of Ordnance.

b. Each lot of small-arms ammunition is graded primarily on the qualities which make that lot especially suitable for use in a particular class of small-arms weapons such as aircraft and antiaircraft machine guns, rifles, and ground machine guns (WD SB 9-AMM 4).

c. Each lot of ammunition other than small-arms ammunition is graded as a result of surveillance tests into one of four grades, depending on its serviceability (WD SB 9-AMM 1).



RA PD 97768

Figure 1 — Color Identification of Small-arms Ammunition Types

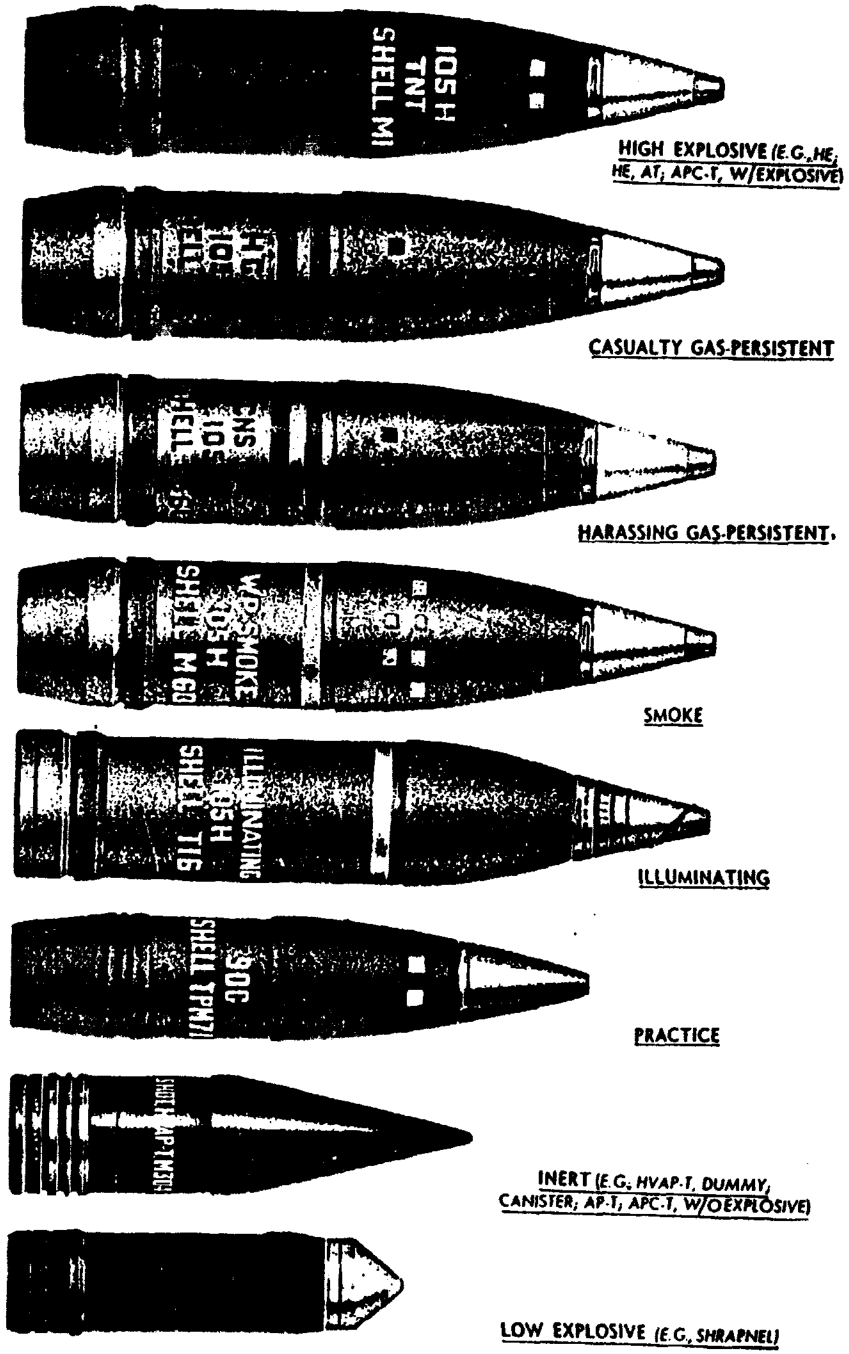


Figure 2 — Color Identification of Artillery Projectiles

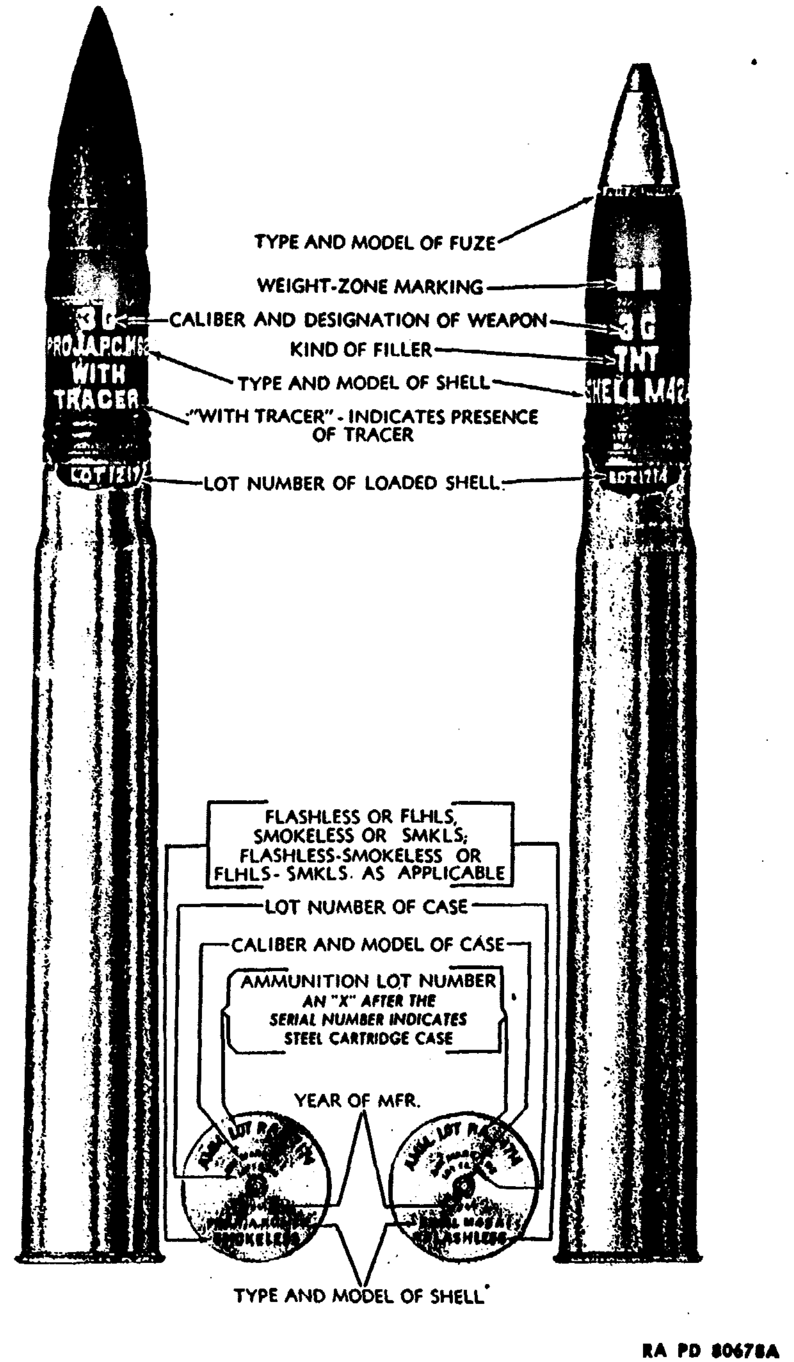
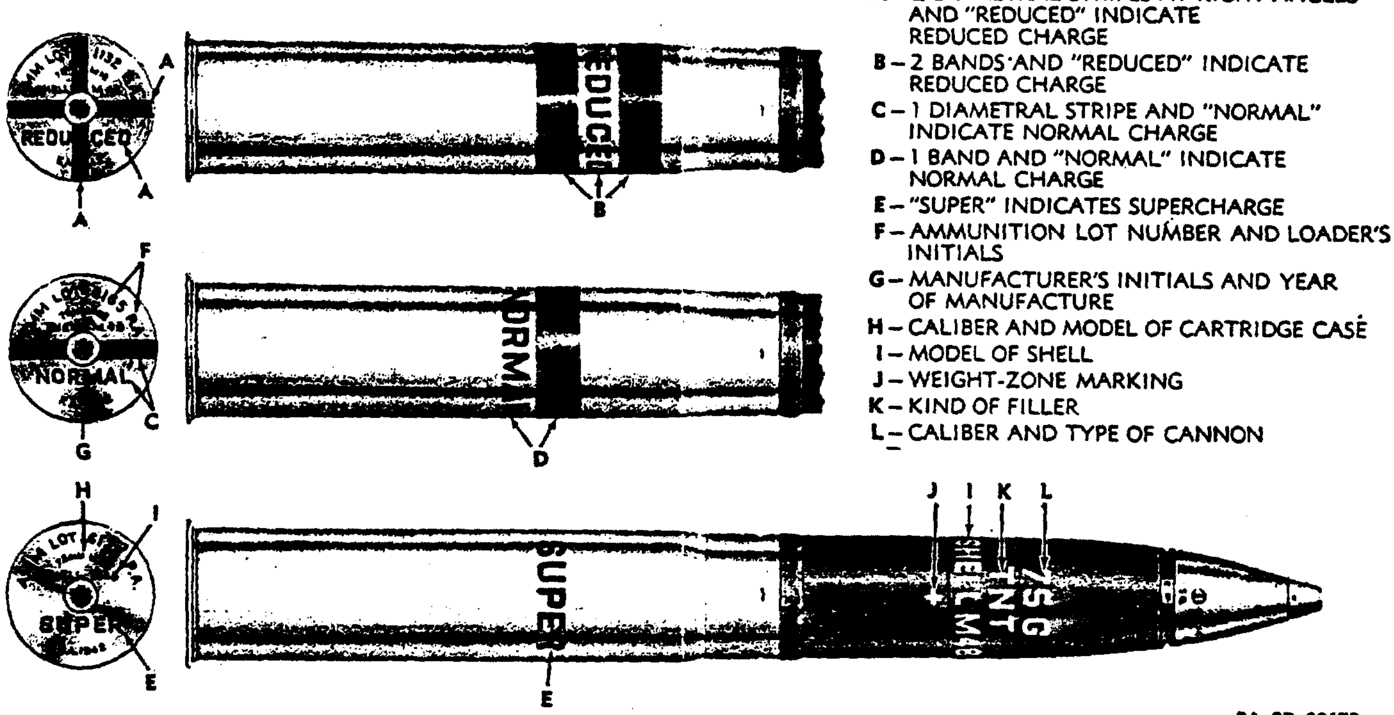


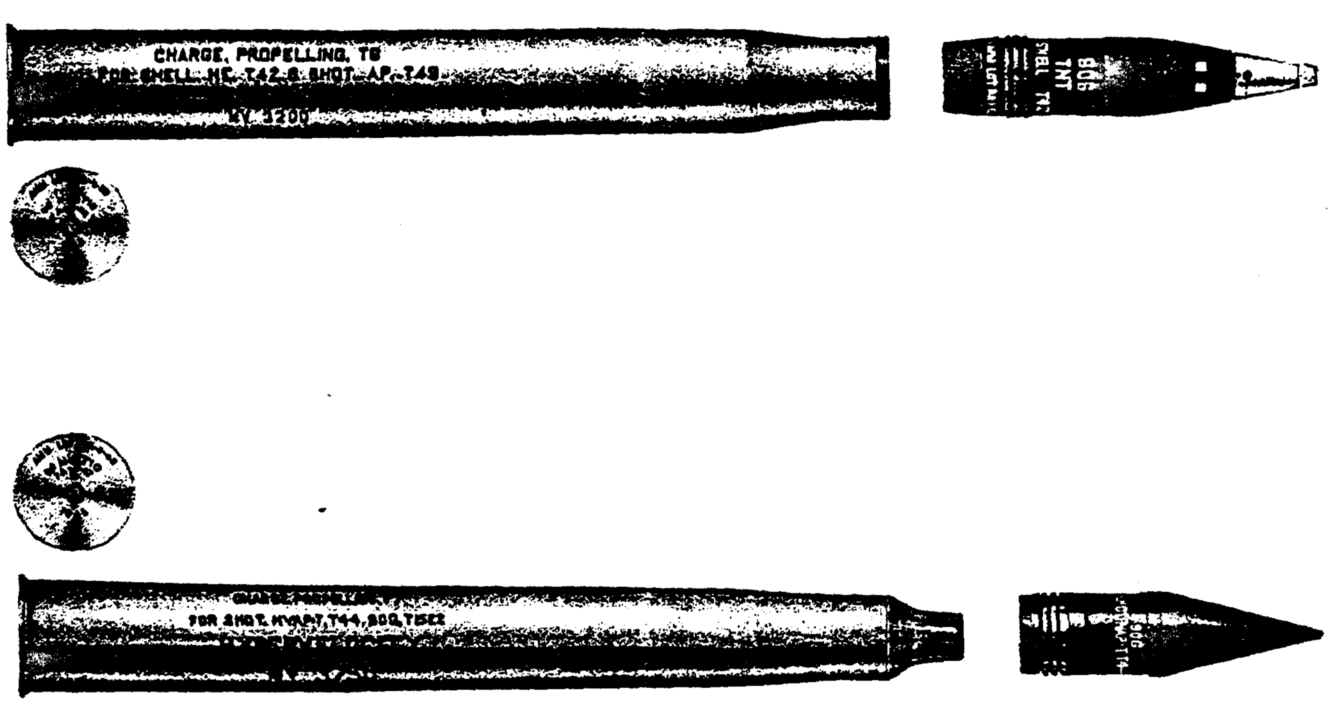
Figure 3 — Typical Marking of Fixed Artillery Ammunition

A – 2 DIAMETRAL STRIPES AT RIGHT ANGLES AND "REDUCED" INDICATE REDUCED CHARGE
B – 2 BANDS AND "REDUCED" INDICATE REDUCED CHARGE
C – 1 DIAMETRAL STRIPE AND "NORMAL" INDICATE NORMAL CHARGE
D – 1 BAND AND "NORMAL" INDICATE NORMAL CHARGE
E – "SUPER" INDICATES SUPERCHARGE
F – AMMUNITION LOT NUMBER AND LOADER'S INITIALS
G – MANUFACTURER'S INITIALS AND YEAR OF MANUFACTURE
H – CALIBER AND MODEL OF CARTRIDGE CASE
I – MODEL OF SHELL
J – WEIGHT-ZONE MARKING
K – KIND OF FILLER
L – CALIBER AND TYPE OF CANNON



RA PD 80679

Figure 4 — Marking of Fixed Artillery Ammunition To Indicate Reduced, Normal, and Super Charges



RA PD 97769

Figure 5 — Marking of 90-mm Separated Artillery Ammunition

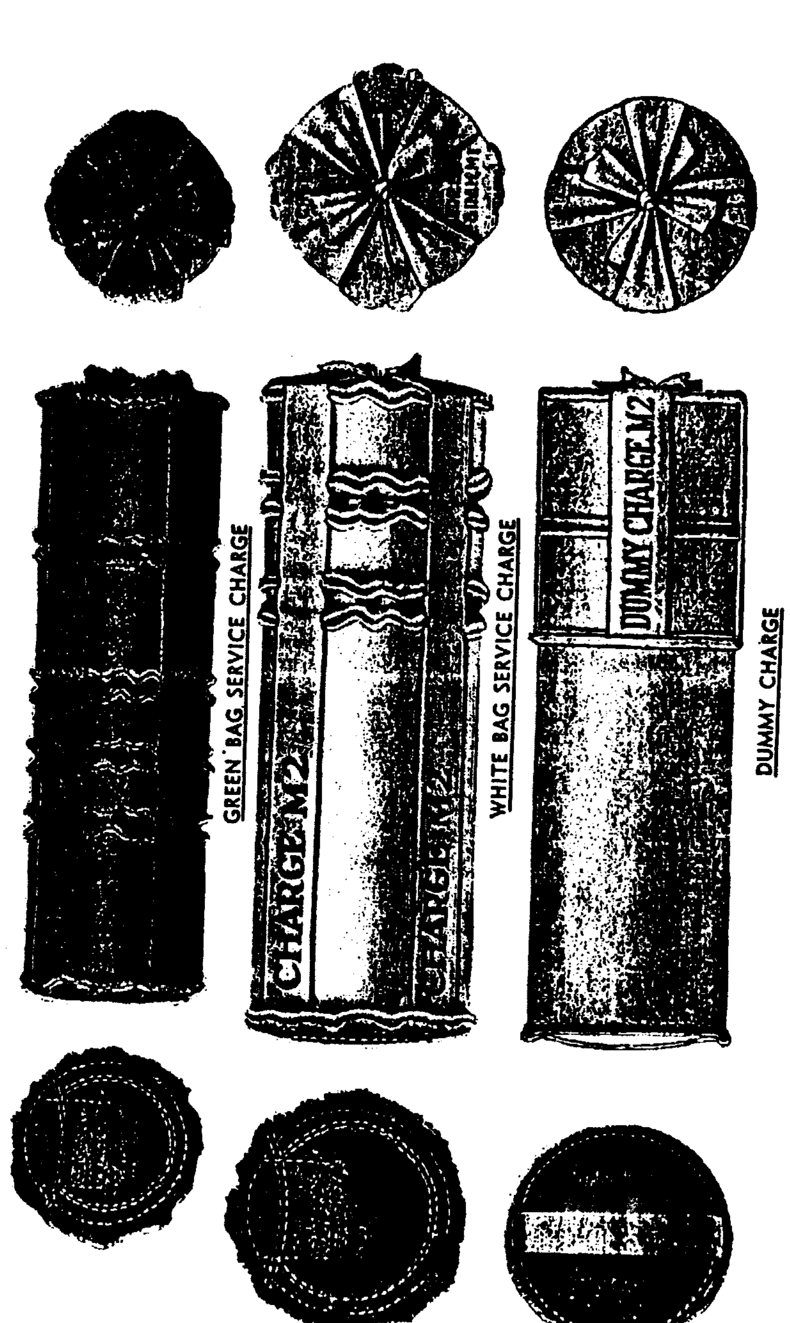


Figure 6 — Color Identification of Artillery Propelling Charges

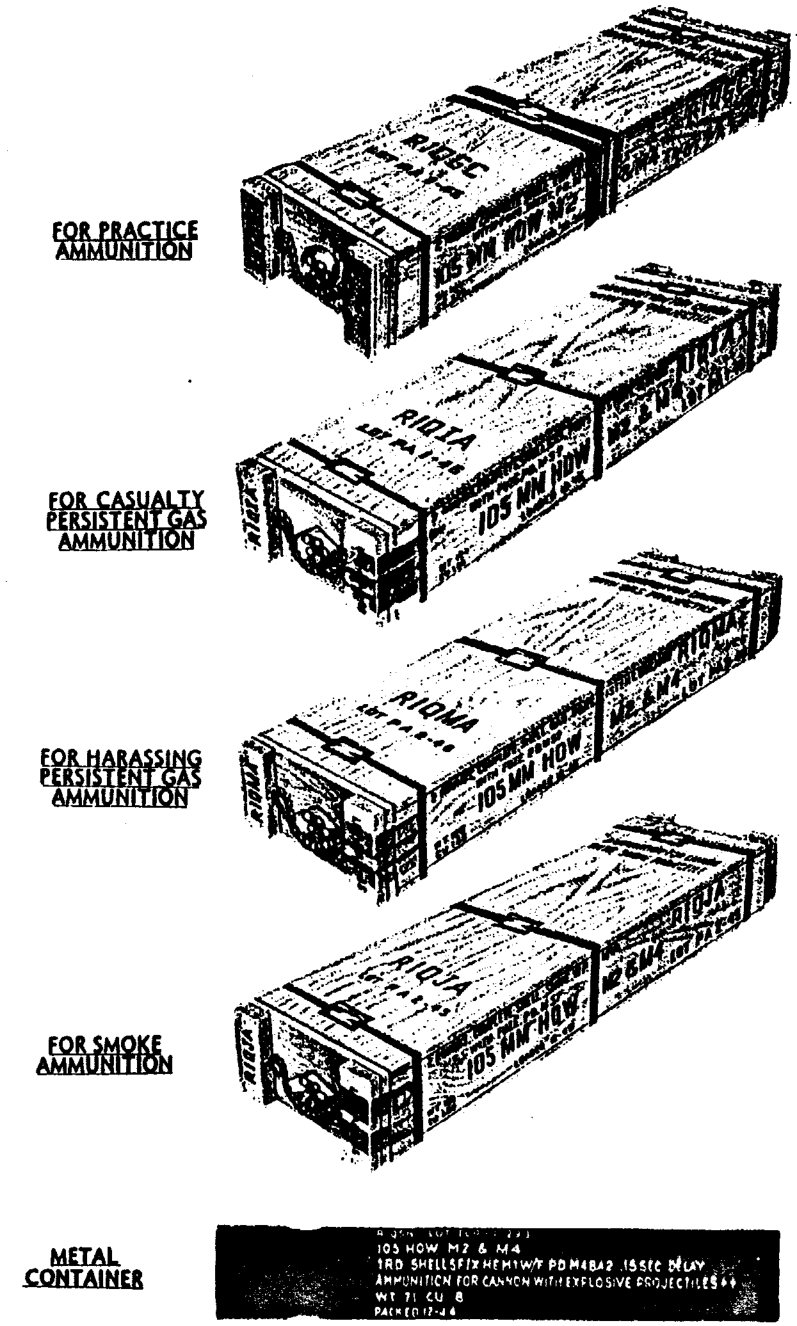


Figure 7 — Color Marking of Packing Boxes and Metal Containers

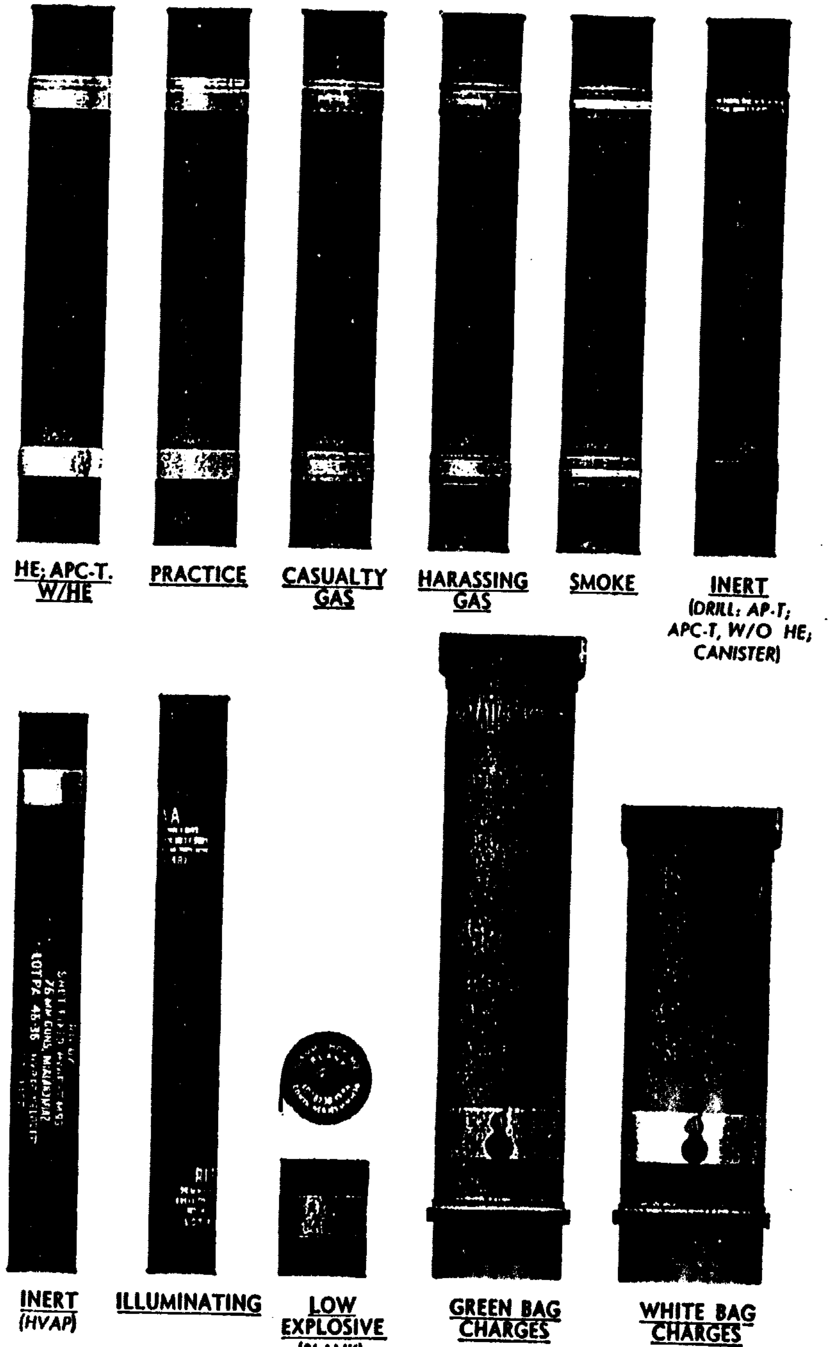


Figure 8 — Color Identification of Fiber Containers and Cartridge Storage Cases

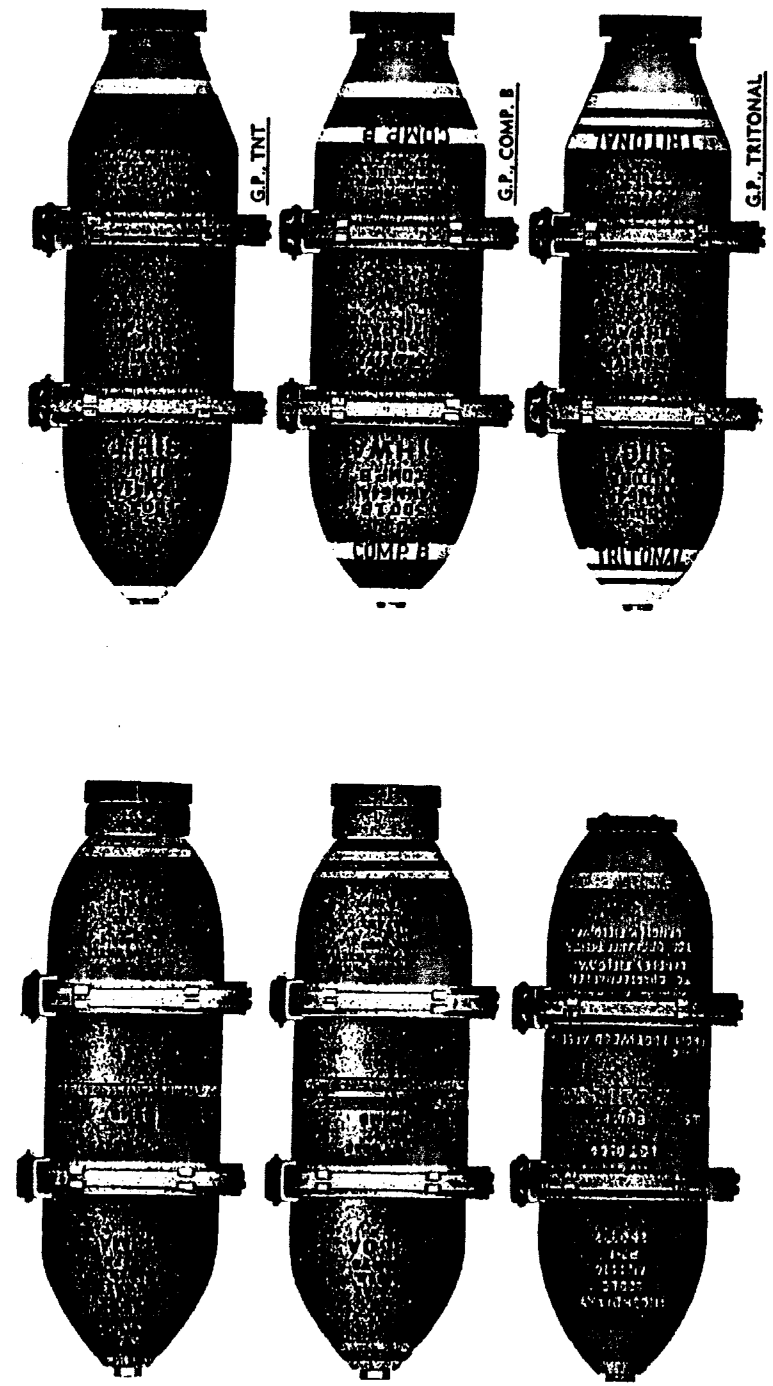
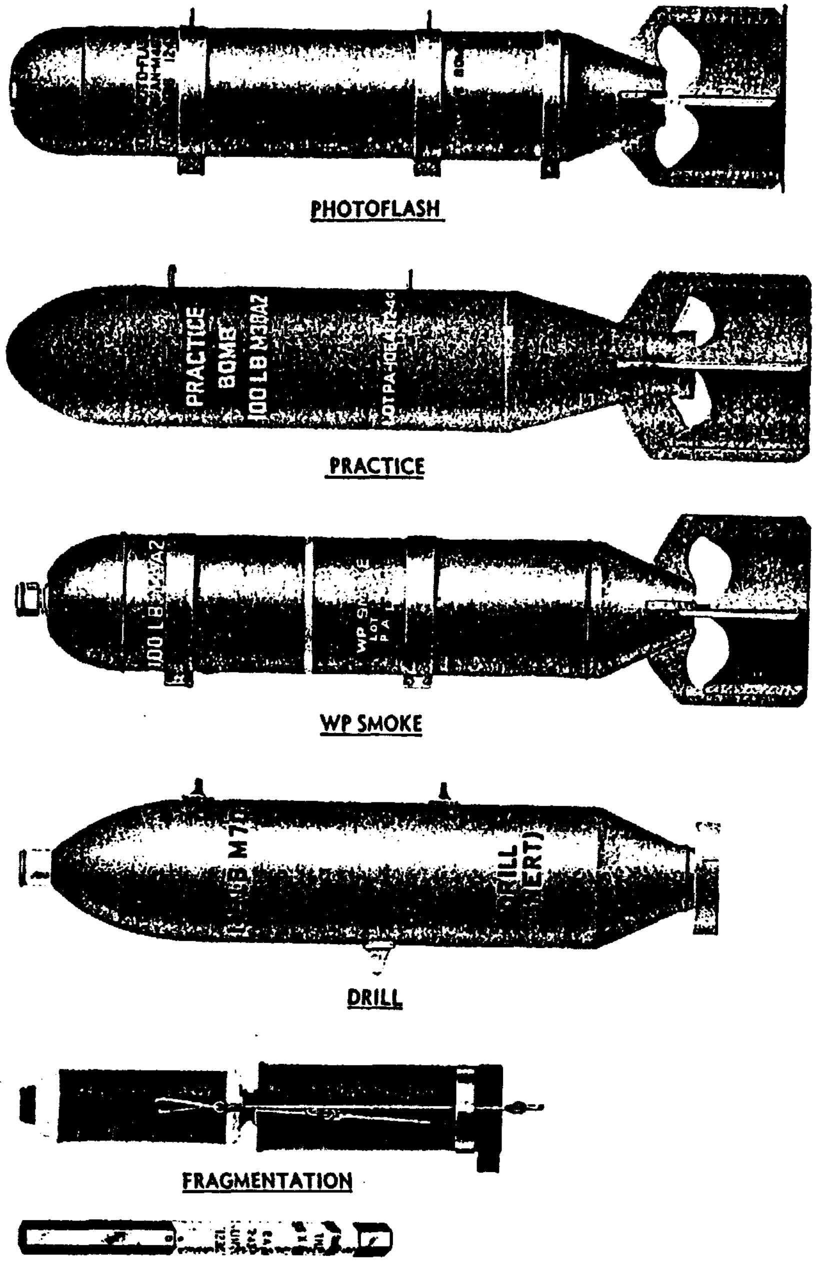
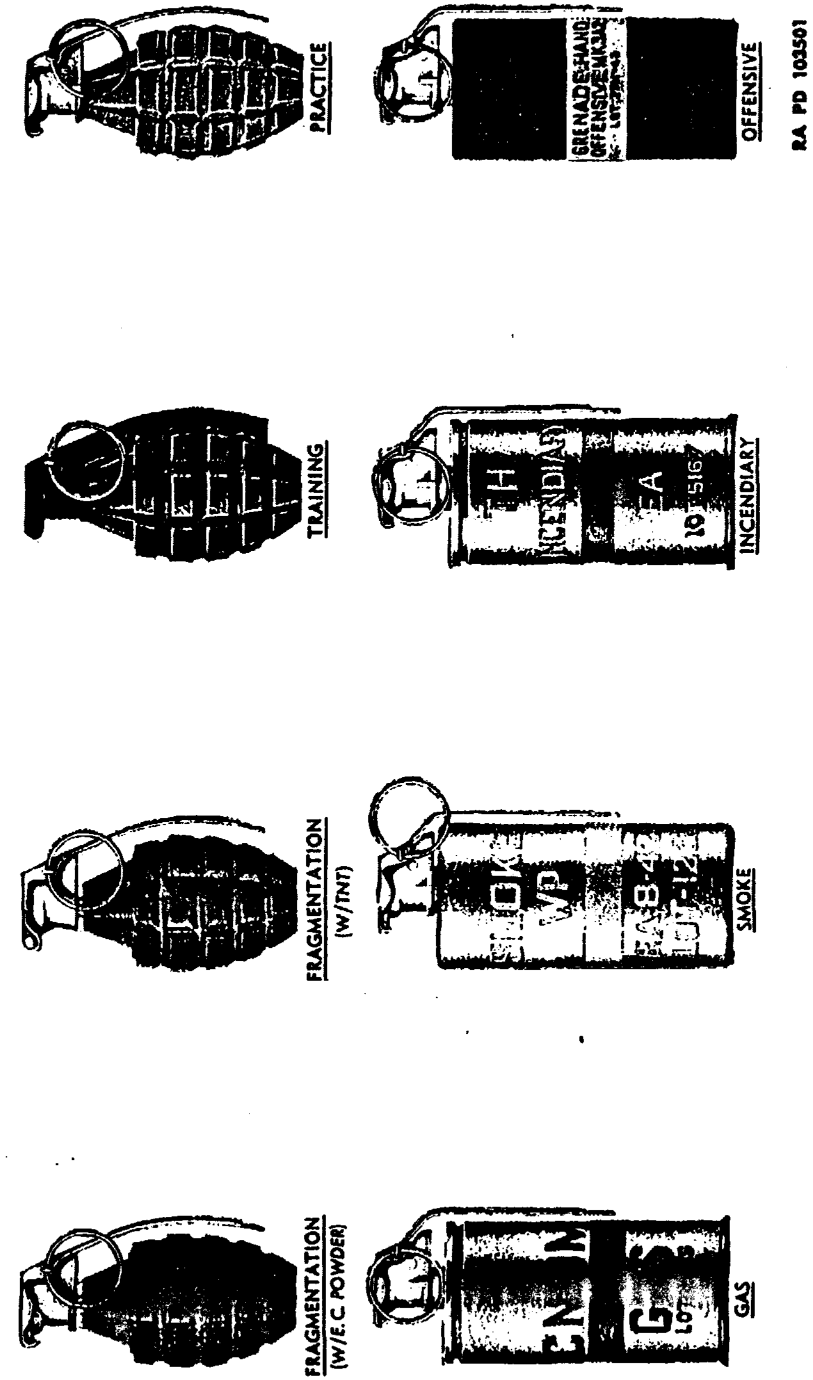


Figure 9 — Color Identification of Bombs



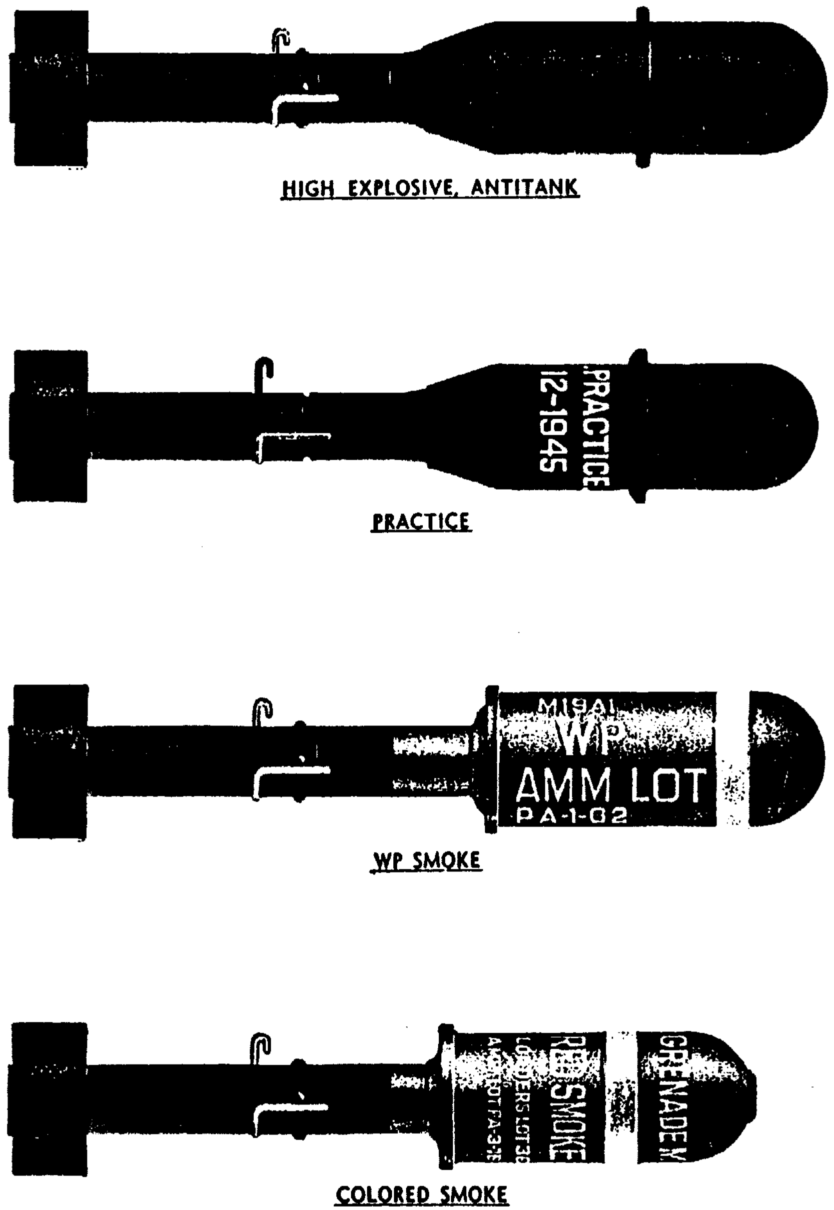
RA PD 103500

Figure 10 — Color Identification of Bombs (Continued)



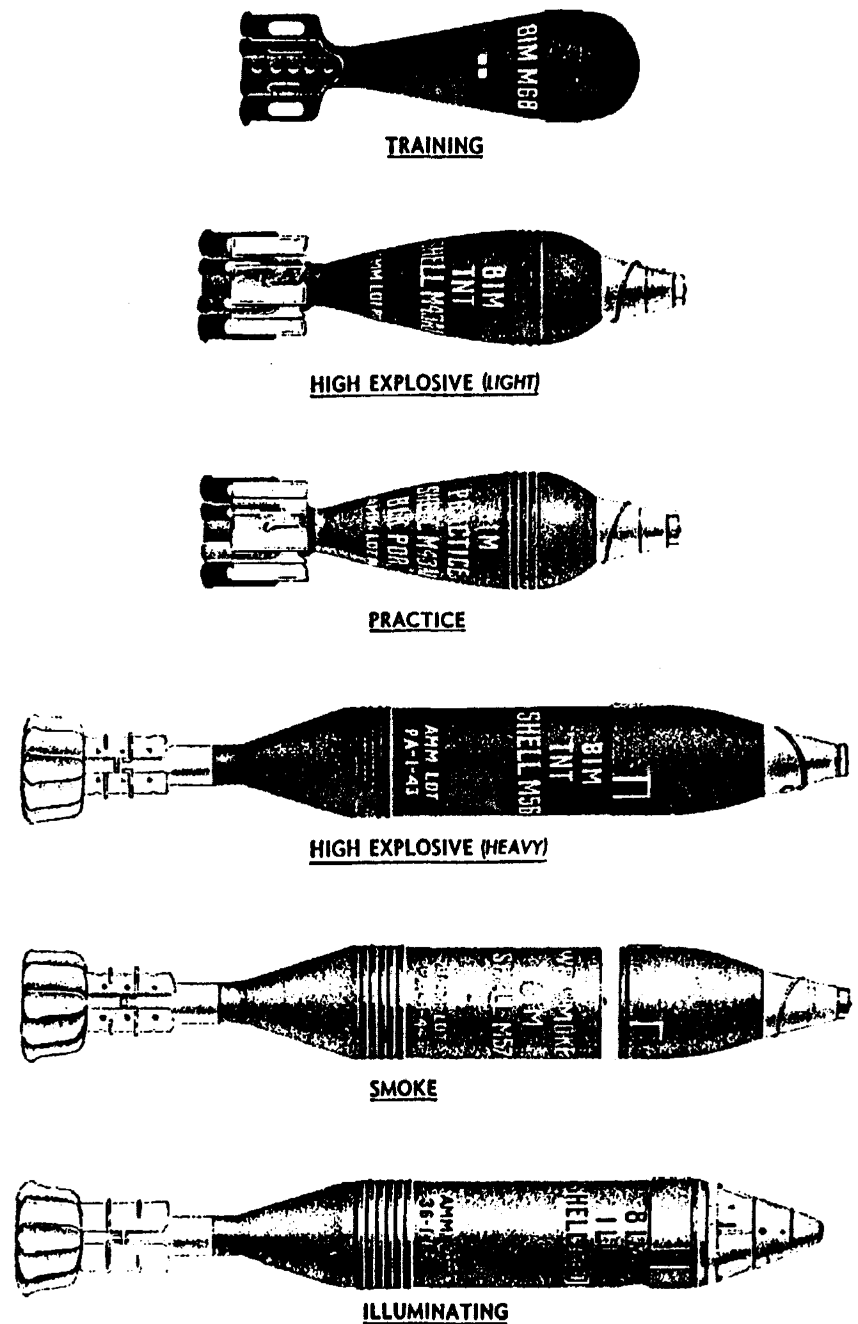
RA PD 103501

Figure 11 — Color Identification of Hand Grenades



RA PD 103502

Figure 12 — Color Identification of Rifle Grenades



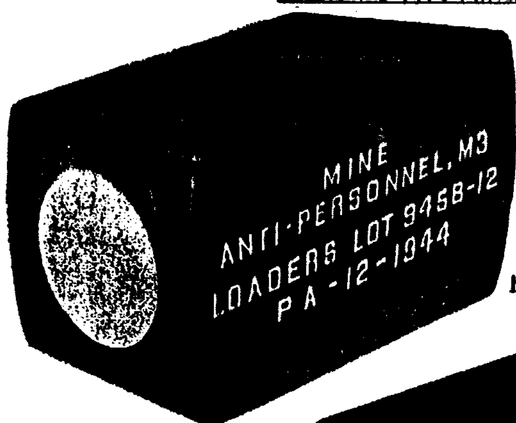
RA PD 103503

Figure 13 — Color Identification of Mortar Shell

HIGH-EXPLOSIVE

PRACTICE

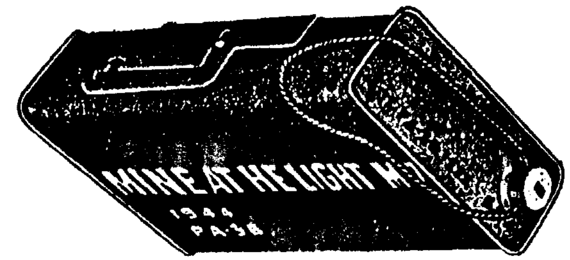
BOUNDING TYPE MINES



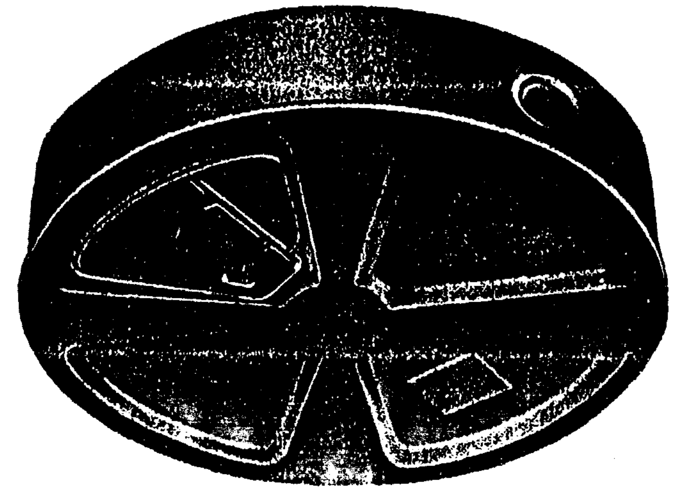
HIGH-EXPLOSIVE

DRILL

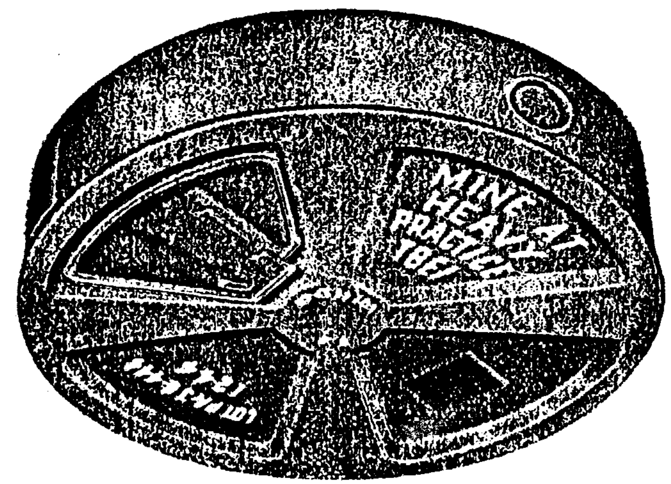
CAST-IRON BLOCK TYPE



LIGHT ANTITANK HE MINE, M7



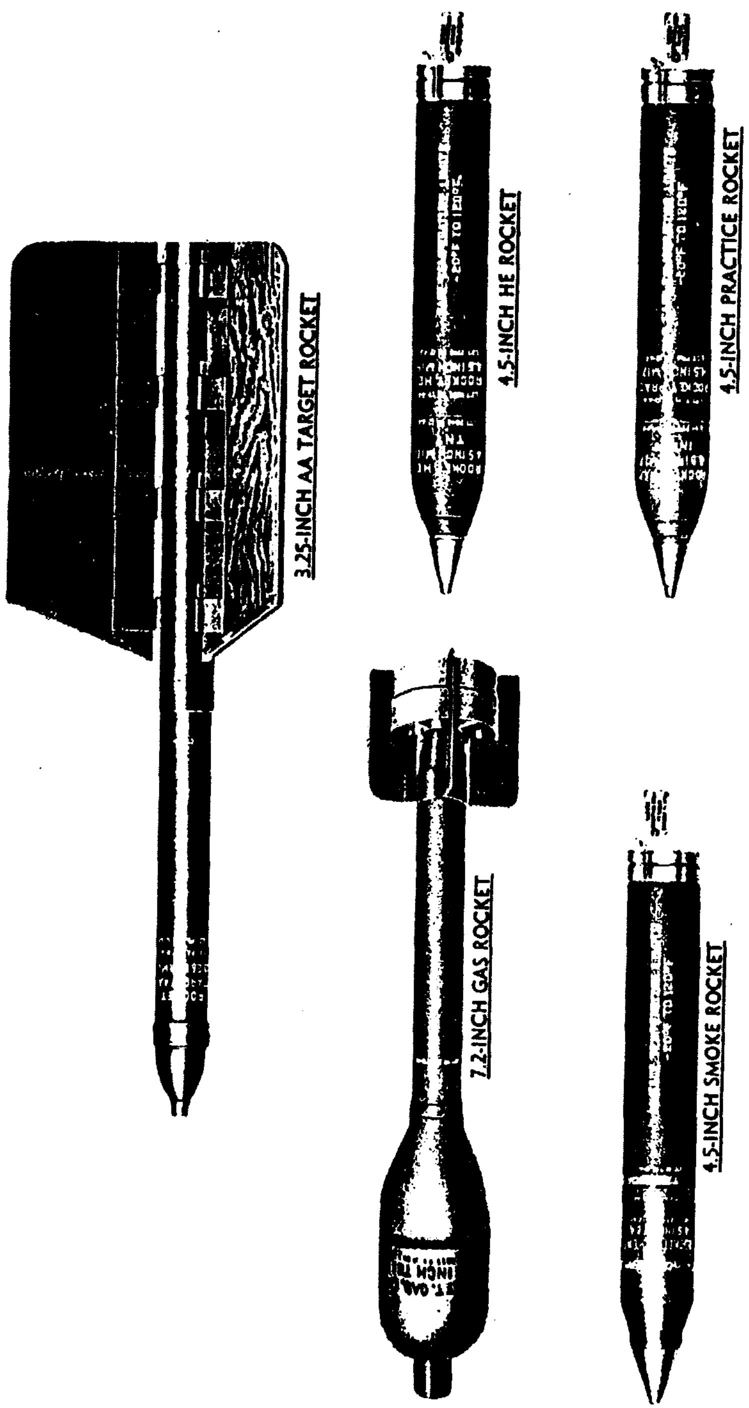
HEAVY ANTITANK HE MINE, M6



HEAVY ANTITANK PRACTICE MINE, T8E1

RA PD 103578

Figure 15 — Color Identification of Antitank Mines



RA PD 103579

Figure 16 — Color Identification of Rockets

9. PRIORITY OF ISSUE.

a. Subject to special instructions from the Chief of Ordnance, ammunition of appropriate type and model will be used in the following order: limited standard, substitute standard, standard. Within this rule, ammunition which has had the longest or least favorable storage will be used first. Among lots of equal age, priority of issue will be given to the smallest lot.

b. To prevent the building up of excess stocks in the field, transfers from one station to another should be arranged within the service command if no stock of appropriate grade for immediate use is on hand.

c. Priority of issue for lots of small-arms ammunition is established by the Chief of Ordnance and published in WD SB 9-AMM 4 or in special instructions.

d. Further details will be found in War Department Supply Bulletins of the 9-AMM series and in AR 775-10.

10. CARE AND PRESERVATION.

a. In order to keep ammunition in a serviceable condition and ready for immediate issue and use, due consideration should be given to the general rules given below. Detailed information on care and preservation is given in chapters 2 and 3.

b. Store ammunition in the original containers in a dry, well-ventilated place protected from the direct rays of the sun and other sources of excessive heat.

c. Keep ammunition and its containers clean and dry and protected from possible damage.

d. Disassembly of components of ammunition, such as fuzes and primers, without specific authorization, is strictly prohibited. Any alteration of loaded ammunition, except by direction of the technical source concerned and under the supervision of a commissioned officer of that service, is hazardous and must not be undertaken.

e. Do not open sealed containers or remove protective or safety devices until just before use, except as required for inspection.

f. *Explosive ammunition must be handled with appropriate care at all times. Explosive elements, such as in primers and fuzes, are sensitive to undue shock and high temperature.*

g. Return ammunition prepared for firing but not fired, to its original packing, and mark it appropriately. Use such ammunition first in subsequent firings in order to keep stocks of opened packings at a minimum.

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Section III

MILITARY EXPLOSIVES

11. GENERAL. To understand the composition and functioning of a complete round of ammunition, a basic knowledge of the characteristics and uses of military explosives is necessary. In order that ammunition may function at time and place desired, it is necessary to employ different kinds of explosives, each of which has a specific role. Explosives suitable for one purpose may be entirely unsatisfactory for another. Thus, the explosive used to burst a forged steel projectile would not only be unsuited but also highly dangerous if used to propel the projectile out of the weapon. Similarly, the explosives used in initiators, such as in primers and fuzes, are so sensitive to shock that only small quantities can be used safely. The characteristics of various types of explosives are given in sections IV and V. For further information, see TM 4-205 and TM 9-2900.

12. DEFINITION. Any mixture or compound which, under the influence of heat or mechanical action, undergoes a sudden chemical change (decomposition) with the liberation of heat and light energy accompanied by a large volume of gases, is called an explosive.

13. CLASSIFICATION.

a. Explosives are classified as low and high explosives according to their rates of decomposition when such decomposition is initiated by the spit of a flame or a mechanical shock. A more exact classification for military purposes distinguishes between nonpropagating and self-propagating explosives. Therefore, explosives are divided into two basic groups: Low explosives (propellants) and high explosives.

(1) LOW EXPLOSIVES. Low explosives are combustible materials which decompose very rapidly but do not normally explode; this action is called deflagration. In decomposition, they produce a large volume of gases which produce enough pressure to propel a projectile or rocket forward. The rate of burning is an important factor and depends upon such factors as pressure, grain form, composition, etc. Low explosives do not usually propagate a detonation. Under certain conditions, however, they react in the same manner as high explosives, that is, they may detonate.

(2) HIGH EXPLOSIVES. High explosives are characterized by the extreme rapidity with which the decomposition occurs; this action is called detonation. They decompose almost instantaneously, either in a manner similar to an extremely rapid combustion, or with rupture and rearrangement of the molecules themselves. In either case, gaseous and/or solid products of reaction are produced. The disruptive effect of the reaction makes the explosive valuable as a bursting charge but precludes its use as a propellant because the gases are

formed so quickly that excessive pressures would be developed which might burst the barrel of the weapon. A detonation may be pictured as resulting from an explosion wave traveling through the high-explosive charge at an extremely high velocity (22,000 to 27,500 feet per second).

14. REQUIREMENTS OF AN EXPLOSIVE.

a. **General military requirements.** Before an explosive can be adopted for military use, it must have the following characteristics:

(1) Chemical stability over extended periods of storage under normal conditions.

(2) Ability to withstand the mechanical shocks incident to loading, transporting, and handling.

(3) Ability to withstand the shock of set-back on firing weapon (when used in artillery shell), or impact when dropped "safe" (when used in bombs).

(4) Susceptibility to complete ignition or detonation under the action of the preceding element of the explosive train.

(5) Brisance (shattering ability).

(6) A reasonable degree of economy in manufacture.

b. **Specific military requirements.** Additional requirements, differing from the basic ones, must be established to make sure that the explosive will perform properly in the capacity desired. In determining by tests whether a given explosive will meet the requirements, consideration must be given to stability, sensitivity, and brisance.

(1) STABILITY. Stability refers to the capacity of an explosive to retain unaltered its chemical and physical properties during an indefinite period of storage, under normal conditions or at higher than normal temperatures.

(2) SENSITIVITY.

(a) To shock or impact. Sensitivity to impact or shock refers to the ease with which an explosive can be detonated by the sudden application of mechanical force.

(b) To detonation by means of initiators. The standard sensitivity to detonation by initiating agents other than mechanical impact is expressed in terms of the amount of initiating explosive as, for example, mercury fulminate required to effect complete detonation of a given weight of explosive under a given set of conditions.

(3) BRISANCE. Brisance is the ability of a detonating explosive to shatter material close to it. This property is different from the potential heat energy of the explosive, sometimes referred to as power or strength, which determines the force an explosive can exert when it explodes. Such force depends upon the amount of gas generated and the temperature reached during an explosion, whereas brisance

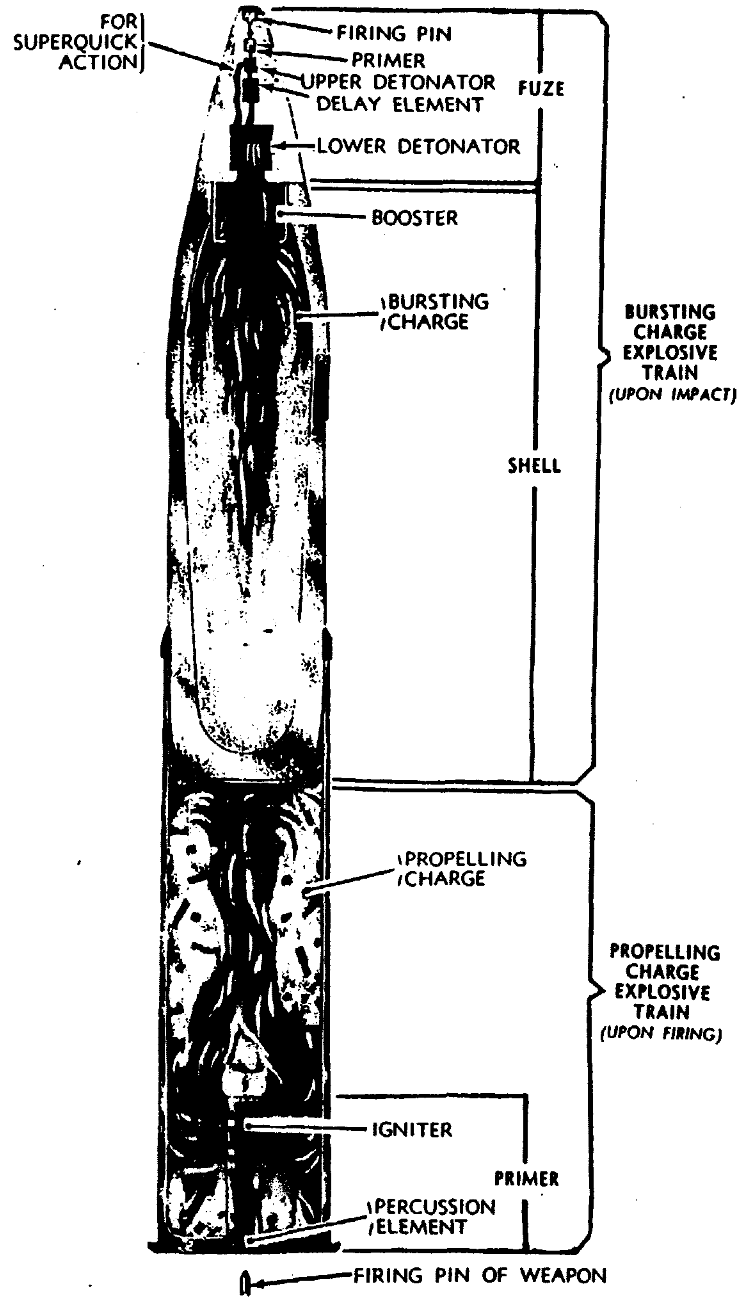

Figure 17 — Explosive Trains in Artillery Ammunition

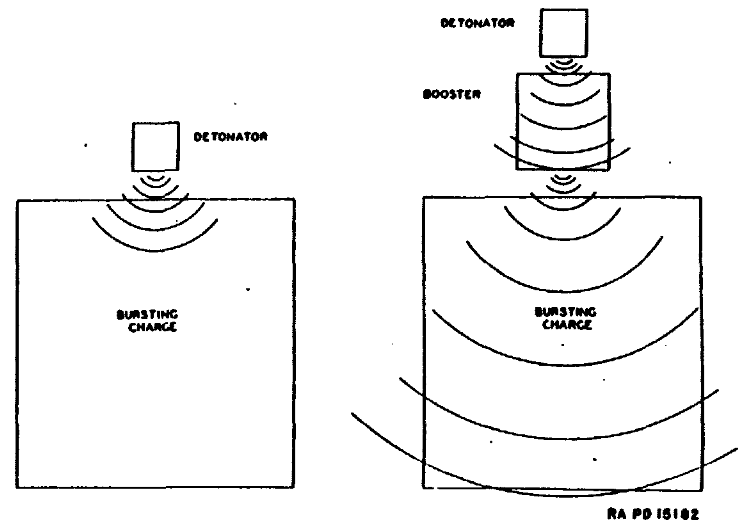

Figure 18 — Detonating Wave Amplified by Use of Booster

depends on the velocity with which a detonation occurs. Black powder, for instance, is a "powerful" explosive because of the large amount of gas that it generates upon explosion, but its brisance is very low because of the low rate of explosion.

15. EXPLOSIVE TRAINS.

a. **General.** The arrangement of a series of explosives beginning with a small quantity of sensitive explosive and terminating with a relatively large quantity of comparatively insensitive explosive, is termed an "explosive train." In general, there are two such trains (fig. 17): the propelling-charge explosive train (which is always a low-explosive train), and the bursting-charge explosive train (which may be either a high- or low-explosive train). In all explosive ammunition one or both of these explosive trains will be found.

b. **Propelling-charge explosive train.** The propelling-charge explosive train is employed in the ejection of the projectile from the weapon on its way toward its target. This train usually consists of a primer, an igniter or igniting charge, and a propelling charge. Thus, a spit of fire from a small quantity of sensitive explosive (the primer), initiated by a blow from the firing pin, is transmitted and intensified (by the igniter) so that a large amount of relatively insensitive explosive (the propelling charge) burns in the proper manner to propel the shell forward.

(1) SMALL-ARMS AMMUNITION. In small-arms cartridges, where the propelling charge is relatively small, the igniter is not required. The components in this train are a percussion primer and a propelling

charge. The firing pin explodes the primer and the flame passes through the vent leading to the powder chamber and ignites the propelling charge; the expansion of the resultant gases forces the bullet out through the bore of the weapon.

(2) ARTILLERY AMMUNITION. The propelling charge explosion of a round of artillery ammunition is slightly different from the one in small-arms ammunition. In this train, it is necessary to place an auxiliary charge of black powder, called the primer charge or igniter charge, between the primer and the propelling charge. The addition of the primer charge is necessary because the small flame produced by the primer composition is not of sufficient intensity to initiate properly the large quantity of propellent powder. The primer or igniter charge may be contained in the body of the primer, making one assembly of the percussion element of the primer and the primer charge as in fixed ammunition, or it may be divided between the primer body and the igniter pad attached to separate-loading propelling charges.

c. **Bursting-charge explosive trains.**

(1) Although there are two explosive trains—the propelling-charge explosive train and the bursting-charge explosive train—the term "explosive train" as commonly used is intended to mean the bursting-charge explosive train. Bursting-charge explosive trains may be classified as high-explosive trains or low-explosive trains.

(2) LOW-EXPLOSIVE TRAIN. When low-explosive projectiles or other types of missile reach the point of functioning, the series of explosions which takes place is known as the low-explosive train. In base-ejection smoke shell, the explosive train consists of a percussion primer, a time train of black powder, a magazine charge of black powder, and an expelling charge of black powder. The action is initiated by the firing pin of the fuze striking the primer, the resultant flame being transmitted through the components named to the expelling charge. The explosion of the expelling charge forces the smoke canisters out of the base of the projectile.

(3) HIGH-EXPLOSIVE TRAIN. When the projectile or bomb reaches the target or the point at which it is set to function, the series of explosions which takes place in order to detonate the projectile is known as the high-explosive train. The basic components which must be present in practically all high-explosive trains are a detonator, a booster, and a bursting charge. Other elements are sometimes required, but these three charges are fundamental.

(a) The detonator sets up a high-explosive wave when initiated by the stab action of a firing pin or by a flame. This detonation is so small and weak that it will not initiate a high-order detonation in the bursting charge, unless a booster is placed between the two. The booster picks up the small explosive wave from the detonator and

amplifies it to such an extent that the bursting charge is initiated with a high-order detonation (fig. 18).

(b) To gain the action necessary to control the time and place at which an explosive will function, it is necessary to incorporate other components in the high-explosive train. The action desired may be a burst in the air, a burst instantly upon impact with the target, or a burst shortly after the projectile has penetrated the target. The components which may be used to give these various actions are a primer, a black-powder delay pellet or train, an upper detonator, or any combination of these components. Regardless of the arrangement of the components, the basic chain will remain the same, other components being placed in front of the basic chain.

(c) The action which causes a projectile to burst in the air may be obtained by placing a primer, which is fired when the projectile leaves the weapon or when the bomb is dropped, and a black-powder time train in front of the basic chain. The primer ignites the time-train rings, which burn for the length of time for which the fuze is set and, in turn, initiate the action of the detonator, booster, and bursting charge.

(d) To burst the projectile promptly upon impact with the target, a superquick or instantaneous action is necessary. This action is usually obtained by placing an upper detonator in the extreme front of the fuze and a lower detonator in the body near the booster charge. In this manner, the detonating wave is transmitted instantly to the bursting charge.

(e) To permit penetration of the target by the projectile, a delay action is necessary. This is obtained by placing a primer and delay element ahead of the detonator. In some cases this combination of primer and delay is inserted between an upper and lower detonator.

(f) A variation of the high-explosive train is found in chemical shell. In this train there is no large bursting charge such as is found in high-explosive projectiles, as it is only necessary to rupture the shell case and allow the chemical contents to escape. The actual bursting of the case is accomplished by an enlarged booster, known as a burster charge, contained in a tube running down the center of the shell.

Section IV

PROPELLANTS

16. GENERAL. All explosives currently used as propellants have a nitrocellulose base and are commonly known as smokeless powders. Various organic and inorganic substances are added to the nitrocellulose base during manufacture to give improved qualities for special purposes. These powders are distinguished by such terms as

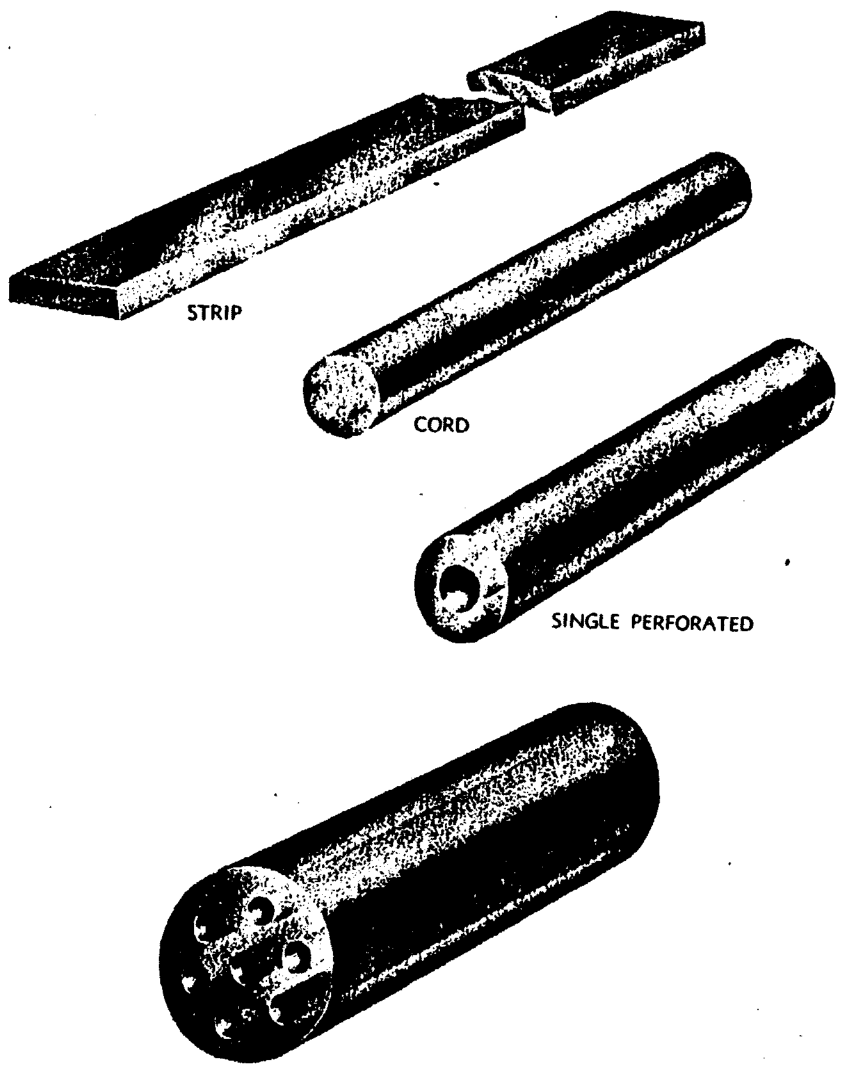

Figure 19 — Types of Powder Grains

double-base, flashless, and smokeless, as well as by commercial trade names or symbols. Black powder, which was formerly classed as a propellant, is no longer used as such but is now used as a delay element, as an igniting charge for propellants, in flash reducers, or for other special purposes.

17. SMOKELESS POWDER.

a. **Characteristics.** Smokeless powder is essentially gelatinized nitrocellulose and is manufactured in the form of flakes, strips, pellets, or perforated cylindrical grains (fig. 19). Powder is made in different shapes to obtain certain types of burning (par. 17 c). The cylindrical grains are made in various diameters and lengths. Grains vary in diameter from 0.032 inch for caliber .30 cartridges to 0.947 inch for 16-inch propelling charges, and vary in corresponding lengths from 0.085 inch to 2.170 inches (fig. 20). For small-size grains either no perforation or a single perforation is required. However, for larger grains, seven equally spaced perforations are present in order to have a large burning surface area (par. 17 c). The critical dimension is the web size, that is, the average thickness of the powder between the perforations. In color, the grains vary from a light amber to a deep brown or black.

b. **Solvent.** Smokeless powder is manufactured to contain in the finished grains a definite amount of solvent (an ether and alcohol mixture). This amount varies from 0.5 to 5 percent. If there is a marked change in the amount of solvent, a change in ballistic properties will result. Powder must be carefully protected against high temperatures and moisture. To guard against changes due to such conditions, smokeless powder is always packed in airtight containers. Some rocket propellent powder may not contain any solvent.

c. **Burning action.**

(1) General. Unconfined smokeless powder burns with little ash or smoke but, when confined, its rate of burning increases with temperature and pressure. In order not to exceed the permissible chamber pressure of the weapon in which it is to be used, the rate of burning of the propellant has to be controlled. At constant pressure, the rate of burning is proportional to the powder surface free to burn. Therefore, powder is made into accurate sizes and definite shapes. Figure 21 illustrates the "progressive" burning of a powder grain.

(2) Degressive burning. As the surface of the cord and strip forms of smokeless powder change with burning, the surface of the grain decreases. The burning action of these grains is, therefore, classified as "degressive."

(3) Neutral burning. As a single-perforated grain burns, the outer surface decreases and the inner surface increases. The result of

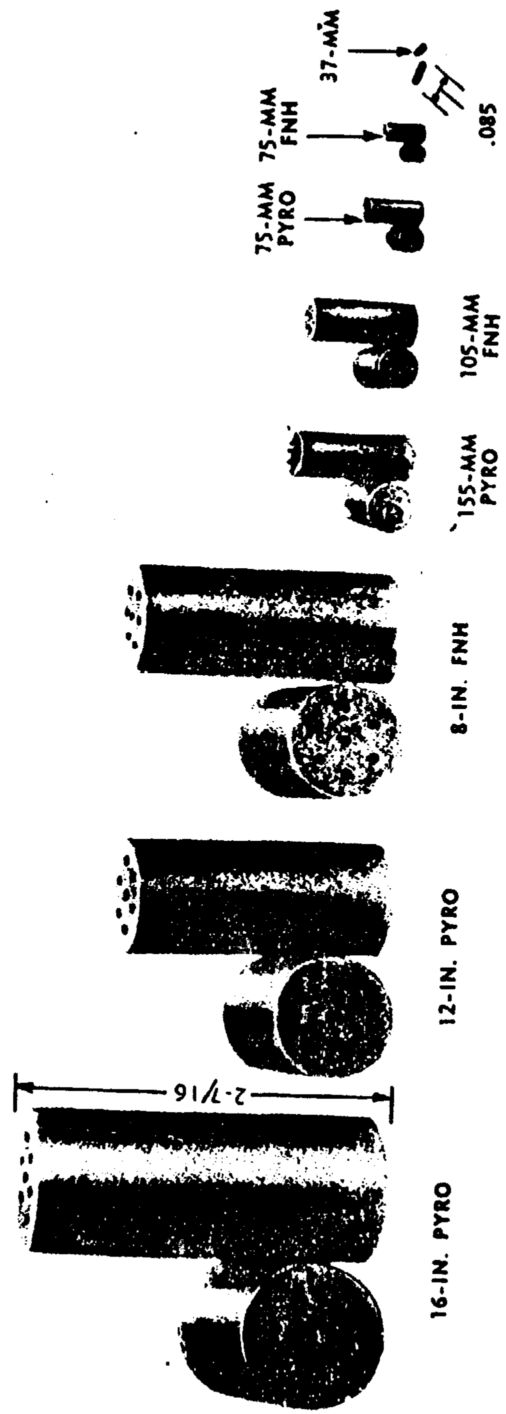

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Figure 20 — Typical Powder Grains — Side and End Views

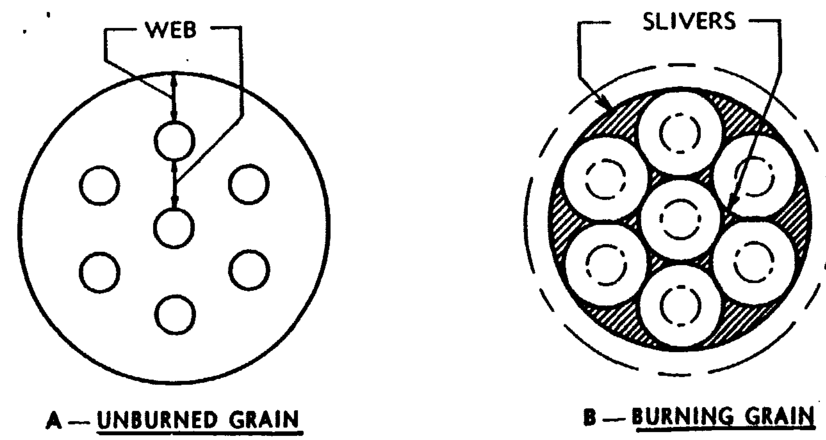

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Figure 21 — Progressive Burning of Powder Grains

the two actions is that the total surface remains approximately the same in area. The burning of this type of grain is known as "neutral."

(4) Progressive burning. When the multiperforated grain burns, the total surface area increases since the perforated grain burns from the inside and outside at the same time. This type of burning is called "progressive" (fig. 21).

(5) Slivers. When a multiperforated grain is not completely consumed, portions of the grain remain in the form of slivers (B, fig. 21) and are normally ejected as such from the weapon.

d. Use. Nitrocellulose smokeless propellants are used as the propellant for small-arms and larger-caliber ammunition. The perforated form of grain is the one most commonly used in United States military powders. Single perforated grains are used for small arms, minor-caliber weapons, and certain howitzers. Powders with seven perforations are used for larger-caliber weapons.

18. DOUBLE-BASE POWDER (BALLISTITE). Ballistite is a combination of nitroglycerin and nitrocellulose, containing approximately 13.15 to 13.25 percent nitrogen obtained by mixing pyro powder (12.6 percent nitrogen) with guncotton (13.35 to 13.4 percent nitrogen). The nitroglycerin serves to increase the potential. Small percentages of inorganic salts are often added to reduce the flash and increase the ease of ignition. Ballistite is used in shotgun shells, field mortar increments, and rocket motors. Double-base powders cause more erosion in the weapon barrel but are being used increasingly because of the higher muzzle velocities obtainable by their use.

19. STANDARD SMOKELESS AND FLASHLESS POWDERS.

a. These powders, which were formerly designated as FNH (flashless-nonhygroscopic) and NH (nonhygroscopic), are a mixture of nitrocellulose and other materials added to cool the products of combustion, thereby reducing the flash and the hygroscopicity, that is, the tendency to absorb moisture. They are used as propellants for most weapons of 37-mm and larger caliber. Nitroglycerin is used in certain powders where especially rapid burning is required and in certain high-velocity rounds and weapons.

b. Rounds of certain caliber, such as 3-inch, 76-mm, and 90-mm, are designated as "flashless," "smokeless," or "flashless-smokeless," dependent upon flash and smoke characteristics upon firing.

c. Whether ammunition upon firing is flashless, smokeless, or both, depends upon the weapons in which used, the type of ignition used, weapon wear, the temperature of the tube of the weapon, and the quantity and design of the propellent powder. Flashless and smokeless are relative terms and have been defined as follows: flashless ammunition does not flash more than 5 percent of the time in weapons of average life under standard conditions; smokeless ammunition produces less than half the amount of smoke produced by ammunition not so designated. A complete round having both these characterstics is designated "flashless-smokeless."

20. GUNCOTTON.

Guncotton, a nitrocellulose of high nitration (13.35 to 13.4 percent nitrogen) is used in the manufacture of propellants. It is also used in electric primers and in trically initiated destructors.

21. EC SMOKELESS POWDER.

EC smokeless powder, or EC blank fire, consists of nitrocellulose with inorganic nitrates. It is usually orange or pink in color and resembles coarse sand, though it is soft and light. It is sensitive to friction, shock, or heat. It absorbs moisture readily and therefore must be protected from the atmosphere. It burns extremely rapidly in the open, but explodes if confined. It is usually exploded by flame from a primer or fuze. It was used at one time as a bursting charge in fragmentation hand grenades. It is used in caliber .30 and caliber .50 blank cartridges, in shotgun shells, and in caliber .22 ammunition.

22. SMALL-ARMS PROPELLANTS.

Smokeless powder for small arms is usually glazed with graphite to facilitate machine loading and to prevent the accumulation of large charges of static electricity, and thus presents a black, polished appearance. Since the powder grains are small, they ignite more readily and burn more freely than cannon powder, and when moisture is present or abnormal temperatures prevail, they are subject to more rapid deterioration than the larger grains. Many small-arms powders are nearly as sensitive to friction

as black powder. Therefore, precautions used in handling black powder should be observed for small-arms powders. In general, there are two types of small-arms propellants, single-base and double-base. A recent type of small-arms powder is in the form of small spherical graphite-coated balls and is used in carbine and caliber .45 ammunition.

23. BLACK POWDER.

a. **General characteristics.** Black powder is an intimate mechanical mixture of finely pulverized potassium nitrate or sodium nitrate, charcoal, and sulfur. The commercial blasting powder with sodium nitrate is now used for saluting purposes. Potassium nitrate is used in the powders for all other military purposes. Black powder is usually in the form of small, black grains which are polished by glazing with graphite. It is subject to rapid deterioration on absorption of moisture, but if kept dry it retains its explosive properties indefinitely. It is one of the most dangerous explosives to handle because it is very easily ignited by heat, friction, or spark.

b. **Uses.** In its several grades, its present military use is practically confined to:

(1) Ignition and primer charges.

(2) Expelling charges for base-ejection smoke shell, illuminating shell, and pyrotechnics.

(3) Delay pellets for primers and fuzes.

(4) Blank ammunition charges.

(5) Smoke-puff and spotting charges.

(6) Bursting charges for practice bombs and shell, and subcaliber shell.

(7) Time-train rings in time and combination fuzes.

c. **Precautions.** Black powder is particularly sensitive to shock, friction, heat, flame, or spark. When black powder is handled in cans or bags or when it is not absolutely protected against sparks, the precautions described in section I of chapter 3 will be strictly observed.

Section V

HIGH EXPLOSIVES

24. GENERAL.

a. High explosives are usually nitration products of organic substances, such as toluene, phenol, pentaerythritol, amines, glycerin, and starch, but may be nitrogen-containing inorganic substances or mixtures of both. Other materials, such as powdered aluminum, plasticizing oils, waxes, rubber, etc., may also be added to explosives to obtain desired characteristics.

b. A high explosive may be a pure compound or an intimate mixture of several ingredients. To avoid confusion in the writing of formulas of mixtures, the following order of listing of components, together with their proportions, has been decided upon: inorganic nitrates/explosives other than TNT/TNT/metals/inert materials. Within any of the preceding groups, the co[illegible]ments are listed alphabetically should there be more than one o[illegible] particular classification.

25. PRIMER MIXTURES.

a. **General.** A primer mixture is an explosive sensitive to a blow such as that imparted by a firing pin. It is used to transmit shock or a flame to another exposive, a time element, or a detonator.

b. **Composition.** In a large number of mixtures, the primer mixture consists of mercury fulminate, potassium chlorate, and antimony sulfide, with or without ground glass and/or a binder. However, the chemicals and materials used may be altered, dependent upon the type of action desired. Primarily, however, a primer mixture consists of an initiating high explosive, an oxygen carrier, and a combustible substance.

c. **Uses.** Primer mixtures are used in the percussion elements of cannon primers, in fuzes, and in small-arms primers, and as the upper layer of a detonator assembly.

26. MERCURY FULMINATE.

a. **Characteristics.** Mercury fulminate is a heavy crystalline solid, white when pure, but ordinarily having a faint brownish-yellow or grayish tint. It is extremely sensitive to heat, friction, spark, flame, or shock, detonating completely in nearly every instance. Its sensitivity varies with temperature. It has been found that its sensitivity is dependent in part on crystal size. It is nonhygroscopic and may be safely stored for long periods of time at moderate temperatures. However, it will not stand long-term storage at elevated temperatures.

b. **Use.** For all practical purposes, mercury fulminate has been replaced by lead azide. Its use is limited to small quantities in a few primers, in fuze detonators, and in blasting caps. It may be used alone or mixed with potassium chlorate.

27. LEAD AZIDE. Lead azide is an initiating compound used to detonate high explosives. It is a fine-grained, cream-colored compound. It is sensitive to flame and impact but it is not certain to detonate by the action of a firing pin. It is not easily decomposed on long continued storage at moderately elevated temperatures. It flashes

at a much higher temperature than mercury fulminate. A smaller weight of lead azide than of mercury fulminate is required to detonate an equal amount of TNT, tetryl, etc. Lead azide is replacing mercury fulminate because of its properties and because it stands up better in storage and is less hazardous to manufacture. It is found in primer mixtures and in detonator assemblies in fuzes.

28. TETRYL.

a. **Characteristics.** Tetryl (trinitrophenylmethylnitramine) is a yellow crystalline solid. When heated it first melts and then decomposes and explodes. It burns readily and is more easily detonated than TNT or ammonium picrate, being much more sensitive than picric acid. It is detonated by friction, shock, or spark. It is practically nonhygroscopic. Tetryl is stable at all temperatures which may be encountered in storage.

b. **Detonation.** Brisance tests show tetryl to have a very high shattering power. It is greater in brisance than picric acid or TNT and is exceeded only by PETN and some of the newer military explosives, such as RDX.

c. **Use.**

(1) CHARGES. Tetryl is the standard booster explosive and is sufficiently insensitive when compressed to be used safely as a booster explosive. The violence of its detonation insures a high-order detonation of the bursting charge. It is used in the form of pressed pellets. Tetryl is the standard bursting charge for small-caliber (20-mm and 37-mm) projectiles. It produces appreciably better fragmentation of these shells than TNT. It is also more readily detonated and yet in small-caliber shell withstands the force of set-back in the weapon. It is also a component of tetrytol.

(2) DETONATOR. Tetryl is used in detonators, the tetryl being pressed into the bottom of the detonator shell and then covered with a small priming charge of mercury fulminate, lead azide, or other initiator.

29. TNT (TRINITROTOLUENE).

a. **General.** Trinitrotoluene, commonly known as TNT, is a constituent of many explosives, such as amatol, pentolite, tetrytol, torpex, tritonal, picratol, cyclator, ednatol, and Composition B, and has been used by itself under such names as triton, trotyl, trilite, trinol, and tritolo.

b. **Characteristics.** TNT when properly purified is one of the most stable of high explosives and can be stored over long periods of time. It is relatively insensitive to blows or friction. Confined TNT, when detonated, explodes with violence. When ignited by a flame, unconfined TNT burns slowly without explosion evolving a heavy oily smoke; however, burning or rapid heating of large quantities, especially in closed vessels, may cause violent detonation. It is readily detonated by mercury fulminate, tetryl, and similar high explosives. It is nonhygroscopic and does not form sensitive compounds with metals, but is readily acted upon by alkalies to form unstable compounds which are very sensitive to heat and inpact. It usually resemblies a light brown sugar but when pure is crystalline and is nearly white. Easily melted and poured into a shell or bomb to form a solid crystalline explosive charge, TNT is a very satisfactory military explosive. The melting point of standard Grade 1 TNT is 80.2° C. Ammunition loaded with TNT can be stored, handled, and shipped with comparative safety.

c. **Exudation.** When stored in warm climates or during warm summer months, some ammunition loaded with TNT may exude an oily brown liquid. This exudate oozes out around the threads at the nose of the shell and may form a pool on the floor. The exudate is inflammable and may carry small particles of TNT. Pools of exudate should be removed as prescribed in paragraph 197.

d. **Detonation.** TNT in crystalline form can be detonated readily by a No. 6 blasting cap or when highly compressed by a No. 8 blasting cap. When cast, it is necessary to use a booster charge of pressed tetryl or an explosive of similar brisance to insure complete detonation.

e. **Use.**

(1) BURSTING CHARGE. TNT is used as a bursting charge for high-explosive shell and bombs either alone or mixed with ammonium nitrate to form 50/50 or 80/20 amatol. Flake TNT is used in 37-mm shell and in fragmentation hand grenades. Other military uses of TNT are in mines and for parts of certain shell and bomb bursters.

(2) DEMOLITION. TNT is used to demolish bridges, railroads, fortifications, and other structures and for land mines. For such purposes TNT is used in the form of a large shaped charge or a small highly compressed block inclosed in a fiber container which protects it from crumbling in handling and renders it waterproof. The triton blocks used by the Corps of Engineers are blocks of pressed TNT inclosed in cardboard containers.

(3) BLASTING. TNT is suitable for all types of blasting and produces approximately the same effect as the same weight of dynamite of 50 to 60 percent grade.

30. AMATOL.

a. **General characteristics.** Amatol, a mechanical mixture of ammonium nitrate and TNT, has approximately the same general characteristics as TNT. It is crystalline, yellow or brownish, and in-

sensitive to friction, but it may be detonated by severe impact. It is less sensitive to detonation than TNT but is readily detonated by mercury fulminate and other high explosives. It is less likely to exude than TNT. It is hygroscopic and in the presence of moisture attacks copper, brass, and bronze, forming dangerously sensitive compounds. Amatol, 50/50, has approximately the same rate of detonation and brisbance as TNT, while 80/20 amatol is slightly lower in velocity and brisance than TNT. Amatol, 80/20, produces a white smoke on detonation, and amatol, 50/50, produces a smoke less black than straight TNT.

b. **Composition and form.** Amatol, 50/50, consists of 50 percent ammonium nitrate and 50 percent TNT by weight. When hot, it is sufficiently fluid to be poured or cast like TNT. Amatol, 80/20, consists of 80 percent ammonium nitrate and 20 percent TNT. It resembles wet brown sugar. When hot, it becomes plastic and in that state is pressed into shells and bombs.

c. **Use.** Amatol is a substitute for TNT. Amatol, 50/50, is used for 3-inch and larger shell, and 80/20 amatol is used for shell of 155-mm and larger. Amatol is also used in large bombs. Its primary use, however, is for bangalore torpedoes.

31. PICRIC ACID (TRINITROPHENOL).

a. **General.** Picric acid, under the name of melinite, was adopted as a military high explosive by the French in 1886 and has been used more extensively as a military explosive by foreign nations than by this country. The British designate it as lyddite.

b. **Characteristics.** Picric acid is a lemon-yellow crystalline solid. It is entirely stable but reacts with metals when moist, forming extremely sensitive compounds. Picric acid is more readily detonated by means of a detonator than TNT but has about the same sensitivity to shock. It is not as toxic as TNT and is also nonhygroscopic although slightly soluble in water. Picric acid has a high melting point —approximately 120° C.

c. **Use.** Picric acid is chiefly used for conversion to ammonium picrate (explosive D) and to form mixtures with other nitro compounds.

32. AMMONIUM PICRATE (EXPLOSIVE D).

a. **Characteristics.** Ammonium picrate is the least sensitive of military explosives to shock and friction. This makes it well suited for use as a bursting charge in armor-piercing projectiles. It is slightly inferior in explosive strength to TNT. When heated, it does not melt but decomposes and explodes. It reacts slowly with metals, and when wet it may form sensitive and dangerous compounds with iron, copper, and lead. It is difficult to detonate but burns readily like tar or resin.

b. **Special precautions.**

(1) Ammonium picrate, which has been pressed at a shell-loading plant and removed from a shell, is very much more sensitive to shock or blow than fresh ammonium picrate. It should be protected against shock or fire and should preferably be stored alone in a building.

(2) Although less sensitive than TNT, it can be exploded by severe shock or friction, is highly inflammable, and may detonate when heated to a high temperature.

c. **Use.** Explosive D is used as a bursting charge for armor-piercing shell, in projectiles for seacoast cannon, and in other types of projectiles which must withstand severe shock and stresses before detonating.

33. PICRATOL.

a. **General.** Picratol is a mixture of 52 percent explosive D and 48 percent TNT. It can be poured like straight TNT and has approximately the same resistance to shock as that of straight explosive D. The brisance of picratol is between that of exlposive D and TNT. Picratol is nonhygroscopic.

b. **Use.** Picratol is a standard filler for all Army semi-armor-piercing bombs.

34. NITROSTARCH EXPLOSIVES.

a. **Characteristics.** Nitrostarch is a white finely divided material similar in appearance to ordinary powdered starch. It is considerably more sensitive to friction and impact than TNT, consequently the crushing or breaking of the explosive is hazardous. Nitrostarch is less sensitive than dry guncotton or nitroglycerin. It is highly inflammable, can be ignited by the slightest spark such as may result from friction, and burns with explosive violence.

b. **Detonation.** Nitrostarch explosives are readily detonated by a No. 6 blasting cap.

c. **Use.** A nitrostarch demolition explosive, consisting of ½-pound or 1-pound (four ¼-pound) blocks, has been adopted as a substitute for TNT. TNT formulas for computing small charges are directly applicable to the nitrostarch demolition explosive. These blocks must not be broken into fragments, as this may cause detonation.

35. PETN (PENTAERYTHRITE TETRANITRATE).

a. **Characteristics.** PETN has a velocity of detonation greater than that of TNT and is more sensitive to shock or friction than TNT or tetryl. In its pure form, PETN is a white crystalline powder; however, it may be a light gray due to other ingredients. It will detonate under a long, slow pressure. PETN in bulk must be stored wet.

b. **Uses.** PETN is suspended in TNT to form pentolite, an explosive of high brisance. It is also used as the explosive core of primacord fuze—a detonating cord which is widely used in demolition work.

36. PENTOLITE.

Pentolite consists of PETN in a TNT matrix. It is superior to TNT in explosive strength and is less sensitive than PETN. Pentolite 50/50 may be melt-loaded. It is, therefore, satisfactory for use in grenades, rockets, high-explosive-antitank shell, and in shaped charges.

37. TETRYTOL.

a. **Characteristics.** Tetrytol is a mixture of 75 percent tetryl and 25 percent TNT. It has higher brisance than TNT and is more effective in cutting through steel and in demolition work. It is less sensitive to shock and friction than tetryl and only slightly more sensitive than TNT. Tetrytol is nonhygroscopic and is suitable for underwater demolition since submergence for 24 hours does not appreciably effect its characteristics.

b. **Use.** Tetrytol is used in chain and individual demolition blocks and in certain destructors.

38. DYNAMITE.

a. **General.** Commercial high explosives are more familiarly referred to as dynamite. There are several types, each type being subdivided into a series of grades. Each type and grade differs in one or more characteristics. Dynamite consists of nitroglycerin absorbed in a porous material. The porous composition varies, depending on the type of dynamite. Dynamite is generally available as paraffin-coated ½-lb sticks or cartridges and is rated according to the percent by weight of nitroglycerin content.

b. **Characteristics.** Dynamite of from 50- to 60-percent nitroglycerin content is equivalent on an equal weight basis to TNT in explosive strength. Dynamite of 40 percent is equivalent to TNT in the ratio of 1¼-pound dynamite to 1-pound TNT. Straight dynamite is more sensitive to shock and friction than TNT and is capable of being detonated by the action of a rifle bullet. The higher percentages of dynamite have very good water resistance. Explosion of the common types of dynamite produces poisonous fumes which are dangerous in confined places.

c. **Use.** Dynamite is used as a substitute for nitrostarch or TNT and for training purposes. The following limitations are placed on its use:

(1) Not to be issued or used for destruction of "duds."

(2) Not to be supplied for training in use of demolition equipment.

(3) Not to be used in Coast Artillery submarine mines or mine batteries.

(4) Not to be carried in combat vehicles subject to extremes of temperature.

39. EDNATOL.

a. **General characteristics.** Ednatol is a mixture of haleite or explosive H (ethylenedinitramine) and TNT, and is one of the most powerful explosives. It is less sensitive than tetryl, PETN, or RDX. Ednatol is equivalent to tetryl in brisance. It can be cast in the same manner as amatol. It has no tendency to combine with metals in the absence of moisture and has no toxic effect. In the presence of moisture, haleite hydrolyzes slightly giving an acid reaction, but hydrolysis of ednatol is not appreciable. Ednatol is very stable and can be stored for long periods; it is nonhygroscopic.

b. **Use.** Ednatol may be used for the same purposes as pentolite, namely, in rockets, grenades, and high-explosive-antitank shell.

40. AMMONAL. The term ammonal refers generally to explosive mixtures containing TNT, ammonium nitrate, and powered aluminum, with or without other ingredients such as charcoal. A similar British explosive is minol 2. As a rule, ammonal explosives are insensitive and, because of the aluminum content, detonate with resultant higher temperature, greater blast effect, and brighter flash than other high explosives. They are used in proving ground tests of high-explosive artillery shell for better observation.

41. TRITONAL. Tritonal is a generic term for explosives containing TNT and aluminum, generally in the ratio of 80/20. It produces a greater blast effect than TNT, or Composition B described below. It is used in light-case and general-purpose bombs.

42. RDX. RDX is also known as cyclonite (cyclotrimethylenetrinitramine), CTMTN, C6, hexogen (German), and T4 (Italian). It is a white crystalline solid having a melting point of 202° C. It has about the same power and brisance as PETN. It is more easily initiated by mercury fulminate than is tetryl. It has a high degree of stability in storage. RDX is never used alone but in mixtures with other explosives and/or oils and waxes.

43. TORPEX. Torpex is a gray compound consisting of RDX, TNT, aluminum powder, and beeswax (or similar wax). It is a more powerful but much more sensitive explosive than TNT. Torpex is nonhygroscopic, noncorrosive, and has a very high brisance. Under water it is 50 percent more destructive than TNT, whereas in air the difference is approximately 30 percent. Torpex is used as a bursting charge in mines, torpedoes, and depth charges.

44. COMPOSITION A, A-2, AND A-3. Composition A (COMP. A) is a mixture of RDX and a desensitizer, being semiplastic in nature. Composition A is a mixture incorporated by rolling, whereas Composition A-2 denotes the same explosive prepared by kettle-drying an unrolled mixture, and Composition A-3 a mixture prepared by tray-drying an unrolled product. Composition A-3 is granular in form, resembling tetryl in granulation. It is buff in color and is press-loaded in minor-caliber (20-mm, 37-mm, and 40-mm) shell. It may also be used for boosters, and can be used in armor-piercing shell due to its insensitivity and high brisance.

45. COMPOSITION B. Composition B (COMP. B) is a mixture of RDX, TNT, and beeswax or similar wax. It is a nonplastic material which is cast-loaded. It is one of the most powerful explosives. It is less sensitive than tetryl but more sensitive than TNT. Composition B is an authorized filling for AN (Army-Navy) standard aircraft bombs, mines, and torpedoes, and may be used in boosters for large bombs, demolition charges, and larger-caliber projectiles.

46. COMPOSITION C, C-2, AND C-3.

a. **General.** Composition C, sometimes referred to as P.E., is a plastic explosive containing RDX and an inert plasticizer. Compositions C-2 and C-3 are similar except that an explosive plasticizer is used. Composition C-2 indicates a mixture of RDX plus nitrocotton and an explosive plasticizer containing no tetryl. Composition C-3 consists of RDX plus nitrocotton and plasticizer containing tetryl substituted in part for RDX.

b. **Composition C-2.** This explosive is easily moldable at most temperatures. It withstands water submersion well. It is used in the 2¼-pound demolition block M3.

c. **Composition C-3.** At temperatures between 0° and 110° F, Composition C-3 is plastic or pliable, closely resembling putty. Below –20° F, it becomes hard and brittle. Above 110° F, it becomes soft and, if kept at this temperature, has a tendency to remain a soft mass. It is considerably less sensitive than TNT and may not always be detonated by a No. 8 blasting cap but will always be detonated by the special Engineer Corps blasting cap. The brownish-yellow plastic, however, has considerably greater brisance than TNT and is particularly effective under water. It is used principally as a commando and demolition explosive, either with or without a container. It is also used as a filler in some types of munitions. If its plasticity is lost by long storage at low temperatures, it may be restored to satisfactory plasticity by molding with the hands after warming by immersion in warm water. It must not be exposed to open flame as it catches fire easily and burns with an intense flame. If burned in large quantities, the heat .d may make it explode. Its explosion produces poisonous gases in such quantities that its use in closed spaces is dangerous.

47. PTX-1. This explosive consists of RDX, tetryl, and TNT. It has a pouring temperature of 90 to 95°C and is castable. It is slightly less stable than Composition B and ednatol. In brisance and power it is equivalent to Composition B and 50/50 pentolite. In general, PTX-1 has approximately the same explosive characteristics as 65/35 tetrytol. This composition does not exude and is less sensitive to impact than 65/35 tetrytol.

48. PTX-2. This explosive consists of PETN, RDX, and TNT. It can be poured at 95° C but may be press-loaded or used as a loose filler. It is less sensitive to impact than 50/50 pentolite but more so than Composition B or ednatol. It is more stable than pentolite and it does not exude. PTX-2 is more brisant and is more readily initiated to high-order detonation than any of the binary explosives.

Section VI

CHEMICAL AGENTS

49. DEFINITION. A chemical agent is a substance which, by its ordinary and direct chemical action and in concentrations attainable in the field, produces a toxic or an irritating (harassing) effect, a screening smoke, an incendiary action, or any combination of these. An agent that produces more than one of these effects is classed according to its principal use.

50. CLASSIFICATION. Chemical agents are classified according to tactical use, pathological effect, and purpose, as follows:

a. **War gases.** A gas is an agent which produces either a toxic or irritating physiological effect. Such an agent may be in solid, liquid, or gaseous state, either before or after dispersion. Gases may be persistent (those remaining effective at pont of release for more than 10 minutes) or nonpersistent (those becoming ineffective within 10 minutes). Persistent gases are further divided into moderately persistent (those remaining effective in the open 10 minutes to 12 hours) and highly persistent (those remaining effective in the open longer than 12 hours). These gases are classified as:

(1) CASUALTY GASES.
(a) Blister gases (vesicants)
(b) Choking gases (lung irritants)
(c) Blood and nerve poisons (systemic poisons)

(. .RASSING GASES (irritants):
(a) Vomiting gases (sternutators)
(b) Tear gases (lacrimators)

b. **Screening smokes.**

c. **Incendiaries.**

d. **Simulated war gases.**

51. DESCRIPTION. The type, common name, and symbol of the principal chemical agents are included in the table in figures 22 and 23. The following table includes the symbols and names of chemical agents which are not included in figures 22 and 23 and which may be encountered in the field.

CWS Symbols and Agents in Addition to Figures 6 and 7

H	Levinstein mustard (30 percent impurities)
HD	Purified mustard
HDV	Thickened purified mustard
HVV	Very viscous solution of methyl methacrylate in purified mustard, HD
HP	Solution of phosphorus in Levinstein mustard
HDP	Solution of phosphorus in purified mustard
HN	Nitrogen mustard
HL	Mustard lewisite
CK	Cyanogen chloride
SA	Arsine
AC	Hydrocyanic acid
CNB	Solution of chloracetophenone in benzene and carbon tetrachloride
CN-DM	Burning mixture of CN and DM
KJ	Stannic chloride
NC	Chlorpicrin-stannic chloride
NP	Thickened gasoline, with napalm
IM	Thickened gasoline
F8	Aluminum-barium nitrate mixture
AS	Asbestine suspension
MR	Molasses residuum

Other symbols, such as A1, A2, and D2, may also be encountered but the chemicals associated with them are highly classified for security purposes. A brief description of the principal chemical agents is contained in paragraphs 53 through 58.

52. PAINTING AND MARKING.

a. **Painting.** Chemical ammunition is identified by the base color, gray.

SYMBOL	NAME	CLASS	BANDS / COLOR	LOADING	ODOR	TACTICAL CLASS	PHYSIOLOGICAL EFFECT
H	MUSTARD DICHLORDIETHYLSULFIDE	Gas	2 Green		Garlic Horseradish Mustard		Burns skin or membrane
L	LEWISITE CHLORVINYLDICHLORARSINE	Gas	2 Green		Geraniums		Irritates nasal passages. Later skin burns, poison.
ED	ETHYLDI-CHLORARSINE	Gas	2 Green		Biting Stinging		Causes blisters, sores
PS	CHLORPICRIN NITROCHLOROFORM	Gas	2 Green	+ CG + CN	Flypaper Anise		Causes severe coughing, crying, lung edema
DP	DIPHOSGENE TRICHLOROMETHYL CHLOROFORMATE	Gas	2 Green		Musty Hay Green Corn Ensilage		Causes coughing, breathing hurts, eyes water, toxic
CG	PHOSGENE CARBONYL CHLORIDE	Gas	1 Green		Musty Hay Green Corn Ensilage		Irritates lungs
CL	CHLORINE	Gas	1 Green	+ PS + CG	Highly Pungent		Intense immediate choking
CN *(CNS)	CHLORACETO-PHENONE	Gas (Solution)	1 Red (2 Red)		Apple blossoms		Makes eyes smart, shut tightly, tears flow. Temporary.
BBC	BROMBENZYL-CYANIDE	Gas	2 Red		Sour fruit		Eyes smart, shut, tears flow. Effect lasts some time.
DM	ADAMSITE DIPHENYLAMINE CHLORARSINE	Gas	1 Red	(+CN)	Coal Smoke		Causes sneezing, sick depressed feeling
DA	DIPHENYL-CHLORARSINE	Gas	1 Red		Shoe Polish		Causes sneezing, sick depressed feeling
HC	HC MIXTURE	Smoke	1 Yellow		Sharp-acrid		Harmless
FS	SULFUR TRIOXIDE IN CHLORSULFONIC ACID	Smoke	1 Yellow		Burning matches		Liquid burns skin if allowed to remain
FM	TITANIUM TETRACHLORIDE	Smoke	1 Yellow		Acrid		Harmless
WP	WHITE PHOSPHORUS	Smoke	1 Yellow		Burning matches		Burning pieces adhere to skin, clothing
†TH	THERMIT (THERMITE) IRON OXIDE AND ALUMINUM POWDER	Incendiary	1 Purple		Odorless		5000 degree F heat ignites materials

* CNS, A SOLUTION OF CN IN CHLOROFORM AND CHLORPICRIN, FREQUENTLY USED FOR SHELL FILLING

† THE FILLING OF A MAGNESIUM BOMB WHICH SERVES TO IGNITE THE METAL MAGNESIUM CASING

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Figure 22 — Chemical Ammunition — Explanatory Chart

PROTECTION	FIRST AID	COLOR & STATE		PERSISTENCE	TACTICAL USES
		LOADED	RELEASED		
	Remove clothing. Wash affected parts of body with soapy water. Irrigate eyes with 2% sodium bicarbonate solution	HEAVY DARK, OILY LIQUID	Liquid slowly evaporates	Open - 1 day Woods - 1 week to all winter	To neutralize areas Counter-battery Attack on Personnel
	Apply 2 to 5% solution hydrogen peroxide to skin; wash with soap and water. Irrigate eyes with water or 2% sodium bicarbonate solution	HEAVY DARK, OILY LIQUID	Liquid slowly evaporates	Open - 1 day Woods - 1 week	Similar to Mustard
	Apply 2 to 5% solution hydrogen peroxide to skin; wash with soap and water. Irrigate eyes with water or 2% sodium bicarbonate solution	CLEAR OILY LIQUID	Evaporates at medium rate.	1 hour	Counter-battery Preparation fire Harassing fire
	Wash eyes, keep quiet and warm Do not rub eyes	YELLOW OILY LIQUID	Evaporates like water.	Open 6 hours Woods - 12 hours	Harassing and casualty fire
	Keep quiet and warm Give coffee as a stimulant	COLORLESS LIQUID	Evaporates like water.	30 minutes	Harassing and casualty fire
	Keep quiet and warm Give coffee as a stimulant	COLORLESS LIQUID	Colorless gas	10 to 30 minutes	Surprise attacks, projectiles Gas cloud release For quick physical effect
	Keep quiet and warm Coffee as stimulant	YELLOW LIQUID	Yellow-green gas	10 minutes	Surprise attacks (cloud)
	Wash eyes with water or boric acid. Do not rub or bandage. Wash skin with 4% Na_2SO_3 in 50% Alcohol Solution	WHITE CRYSTALLINE POWDER	Cloud of small, solid particles	10 minutes	Training Mob control CNS used in counter-battery to force mask wear
	Wash eyes with boric acid Do not bandage	DARK BROWN OILY LIQUID	Slowly evaporates	Several days (weeks in winter)	To neutralize areas Counter-battery
	Remove to pure air and keep quiet. Breathe small amounts of chlorine	YELLOW GREEN GRANULAR SOLID	Yellow smoke	10 minutes	Gas Cloud Attacks Mob control -
	Remove to pure air, keep quiet Sniff chlorine from bleaching powder bottle	WHITE CRYSTALLINE SOLID	Vapor or fine smoke	Summer 10 minutes	Harassing fire
NONE NEEDED	Produces no effect requiring treatment	GREY SOLID	White to grey smoke	While burning	To screen small operations in own lines and for training purposes
	Wash with Soda solution	CLEAR TO BROWN LIQUID	Dense white smoke	5 - 10 minutes	Airplane spray for screen on broad front -
NONE NEEDED	Produces no effect requiring treatment	YELLOWISH TO BROWN LIQUID	White smoke	10 minutes	Screening operations
NONE AVAILABLE	Wash with Copper Sulphate solution or immerse in water	PALE YELLOW SOLID	Burns to white smoke in air	10 minutes	To screen advancing troops Cause incendiary effects, losses Harass enemy observers -
COVER WITH EARTH, SAND	Treat for burn	METALLIC POWDER	White-hot metal	5 minutes	Destruction of Material -

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Figure 23 — Chemical Ammunition — Explanatory Chart — Continued

b. Marking. The particular agent used as chemical filler is indicated in the marking on the ammunition by one or two bands and the type of filler and its symbol, all in a distinctive color in accordance with chapter 1, section II.

53. BLISTER GASES. Blister gases produce casualties resultant from injuries to the eyes and lungs and skin blisters. The principal blister gases are mustard gas and lewisite.

a. Mustard gas (H) is a dark-brown liquid which slowly evaporates to a colorless gas having the odor of garlic. Purified mustard (HD) may be practically odorless. Its principal physiological effect is that of a blister gas (vesicant), although the blistering does not ordinarily appear for several hours. If inhaled, the vapors have a choking (lung-irritant) effect. For complete protection against H, both gas mask and protective clothing are necessary. The tactical use of H is to neutralize areas, contaminate materiel, cause casualties, and harass enemy personnel. It is projected by artillery and mortar in shells and from airplanes in bombs and sprays. It is left in land mines by retreating troops. It renders food and water unfit for use.

b. Lewisite (L) is a dark-brown liquid evaporating to a colorless gas which has the odor of geraniums. In addition to being a blister and choking gas, lewisite is an arsenical poison. Gas mask and protective clothing are necessary for protection against L. The tactical use of L and the methods of projection are the same as those for H. It renders food and water permanently unfit for use.

54. CHOKING GASES. Choking gases injure the respiratory tract—nose, throat, and lungs. The principal choking casualty gases are diphosgene, phosgene, chlorine, and chlorpicrin.

a. Diphosgene (DP) has a toxicity about the same as that of phosgene. It causes watering of the eyes, as well as coughing and occasional vomiting.

b. Phosgene (CG) appears on projection as a whitish cloud, changing to a colorless gas. The toxicity is over ten times that of chlorine. In high concentrations, which are often met in battle, one or two breaths may be fatal in a few hours. Unlike chlorine, CG produces but slight irritation of the sensory nerves in the upper air passages, so the men exposed to this gas are likely to inhale it more deeply than they would equivalent concentrations of chlorine or other gases. For this reason, phosgene is very insidious in its action and men gassed with it often have little or no warning symptoms until too late to avoid serious poisoning. Its tactical use, action on metals, food, and water, are the same as for chlorine.

c. Chlorine (Cl) is a greenish-yellow gas with a pungent odor. Physiologically, it acts as a lung irritant. The service gas mask is sufficient for protection. It is used tactically as a casualty agent. It

causes violent coughing immediately and can be fatal on continued exposure. It is used alone and with other of this group in gas-cloud attack from cylinders. It has a vigorous corrosive action on wet or moist metals. Food and water contaminated with chlorine can be made fit for use under the direction of a medical officer.

d. Chlorpicrin (PS) is a colorless oily liquid, changing slowly in the open to a colorless gas. In addition to its lung injurant effects, PS is also a strong tear gas, and has the additional advantage of being capable of penetrating gas mask canisters that are resistant to ordinary acid gases such as chlorine and phosgene. The injurious effects of PS also extend to the stomach and intestines, causing nausea, vomiting, colic, and diarrhea. Since these conditions are difficult to combat in the field and often persist for weeks, even slight cases of PS gassing frequently involve large casualty losses. Tactically, it is used in heavy concentrations as a casualty agent and in lighter concentrations as a harassing agent. PS is used with tear gas in artillery and mortar shells and in airplane bombs and sprays. With phosgene and chlorine, PS is used from cylinders. It has slight action on metals. Contaminated food and water may be rendered fit for use under the direction of a medical officer.

55. BLOOD AND NERVE POISONS. These gases may produce toxic effects very rapidly. The principal blood and nerve poisons are hydrocyanic acid and cyanogen chloride.

a. Hydrocyanic acid (AC) forms a colorless gas upon release. Its odor is similar to that of almonds, but is not always readily detected in the field. Its action is very rapid. Its first action is stimulation of the respiratory system, causing deeper inhalation. Death by paralysis of the respiratory system may occur in a few minutes.

b. Cyanogen chloride (CK) forms a colorless gas upon release and has a sharp pungent odor. Its action is very rapid and produces paralysis of the respiratory system. Unlike AC, it first produces an involuntary spasm of short duration of the upper respiratory tract.

56. HARASSING GASES. The harassing gases (irritants) are the tear and vomiting gases. The principal ones are:

a. Chloracetophenone (CN), commonly known as tear gas, is typical of the tear gases. It produces profuse weeping and requires the use of a gas mask for protection. It has no permanently injurious effect on the eyes. In higher concentrations, it irritates the skin, producing a burning and itching sensation. CN is used alone in grenades. It is used in benzene and carbon tetrachloride solution alone (CNB) and in chloroform solution with chlorpicrin (CNS) in artillery and mortar shells and from airplanes in bombs and sprays. CN has slight action on metals. It imparts a disagreeable taste to food and water.

b. Brombenzylcyanide (BBC) is a tear gas which produces a burning sensation of the mucous membranes and severe irritation and lacrimation of the eyes with acute pain in the forehead.

c. Adamsite (DM) typifies the vomiting gases. It is a solid which is dispersed by burning-type munitions such as candles and grenades, and appears as a yellow smoke with an odor resembling coal smoke. Physiologically, it causes lacrimation, violent sneezing, intense headache, nausea, and temporary physical debility. For protection, the service gas mask, which is equipped with an efficient smoke filter, is required. Tactically, it is used as a harassing gas. DM has a slight action on metal and renders food and water permanently unfit for use.

d. Diphenylchlorarsine (DA) is a vomiting gas which causes irritation of the throat and lungs. This is followed by a headache, and pains in the jaws and teeth. These symptoms are accompanied by chest pains, nausea, and vomiting.

57. SCREENING SMOKES. Smokes are produced by the dispersion of particles in the atmosphere through the burning of solids and the spraying of liquids. They are used to screen movements and activity, to blanket the enemy, to inactivate observers, to spot artillery fire and bombing, and to disguise cloud gas.

a. Hexachlorethane-zinc mixture (HC) can be used only from burning-type ammunition, such as grenades, candles, and base-ignition and base-ejection smoke shell. No protection of materiel is required. HC is harmful (toxic) to unmasked personnel who are exposed to heavy concentrations for short periods or to light concentrations for extended periods of time, but the service mask offers complete protection. Food and water are not spoiled by HC but acquire a disagreeable odor.

b. Sulfur trioxide-chlorsulfonic acid mixture (FS) is a liquid which produces a dense white smoke when dispersed into a humid atmosphere. It is projected in shells, by airplane spray and from portable cylinders. FS liquid is very corrosive, and rubber gloves should be worn in handling it. No mask is necessary for the smoke, which is harmless to personnel except in very heavy concentrations. Liquid FS renders food and water unfit for use; the smoke merely imparts an unpleasant taste. Because of its corrosive nature, certain restrictions are in force on the use of FS (AR 750-10).

c. Titanium tetrachloride (FM) is similar to FS in appearance, properties, and use.

d. White phosphorus (WP) is a yellow, waxy substance which ignites spontaneously and produces a dense white smoke. Its principal use is to produce smoke, although it is an incendiary and casualty agent as well. WP is used only in explosive-type projectiles,

artillery and mortar shell, grenades, and airplane bombs. When the projectile explodes, it scatters small pieces of phosphorus which ignite spontaneously upon contact with air. These particles continue to burn even when embedded in the flesh. Phosphorus burns should be kept under water or well packed with moist earth until the particles are removed. Phosphorus smoke is unpleasant to breathe but harmless; the particles, however, will poison food and water.

58. INCENDIARIES. Incendiaries are used to ignite combustible materials, but may also injure personnel. Various types of incendiary agents are used. An aluminum-barium nitrate mixture (F8), thermite (TH), or thermate (TH) are used in magnesium or steel containers.

a. Thermite is a mixture of aluminum and iron and this mixture, upon ignition, produces molten iron.

b. Thermate, a mixture of thermite with other substances (such as barium nitrate) which accelerate the burning, is used in incendiary bombs and grenades.

c. Combustible oils and jelled gasoline are used in bombs and flame throwers. Incendiary mixture (PT-1) is used in bombs.

CHAPTER 2

CLASSES OF AMMUNITION

Section I

SMALL-ARMS AMMUNITION

59. GENERAL.

a. Ammunition used in weapons whose bore is 0.60 inch or less (rifles, carbines, pistols, revolvers, and machine guns) and in shotguns is classed as small-arms ammunition.

b. Many types of cartridges are manufactured to the same profile. Consequently, cartridges of the same caliber although of different model may be very similar in appearance. Each type, and sometimes each model, as in the case of some tracer cartridges, has a characteristic colored bullet tip. Cartridges may be identified as to type, model, and caliber by marking on packing boxes and cartons.

c. The colors used on bullet tips to identify the type of cartridge are shown in figure 1 and described in paragraph 7 a (3).

60. CARTRIDGES.

a. **General.** A round of small-arms ammunition is known as a cartridge. In general, it consists of a bullet, a propelling charge, a primer, and a cartridge case, all assembled into a unit assembly (figs. 24, 25, and 26).

b. **Bullet.** Bullets for service use have a metal core or slug which is covered with a gilding metal, or gilding-metal-clad steel jacket. In the case of caliber .45 bullets, copper-plated steel may be used instead of gilding metal for the jacket. Ball and tracer bullets have a lead alloy or common steel core or slug, whereas armor-piercing bullets have a hardened steel alloy core. Bullets have a flat or tapered base. A bullet having a tapered base is said to be "boat-tailed." A cannelure, or annular knurl, is rolled or cut into the jacket to provide a recess into which the cartridge case is crimped (figs. 27, 28, 29, and 30).

c. **Propelling charge.** There are two types of small-arms propellants generally used, the single-base nitrocellulose type and the double-base type. The double-base type is a mixture of nitrocellulose and nitroglycerin which burns more rapidly than the single-base type; it is used in shotgun shells, some caliber .45 rounds, and carbine ammunition. The weight of the charge and granulation of the powder are in accordance with specification requirements for velocity and pressure. The charge is assembled loosely in the cartridge case.

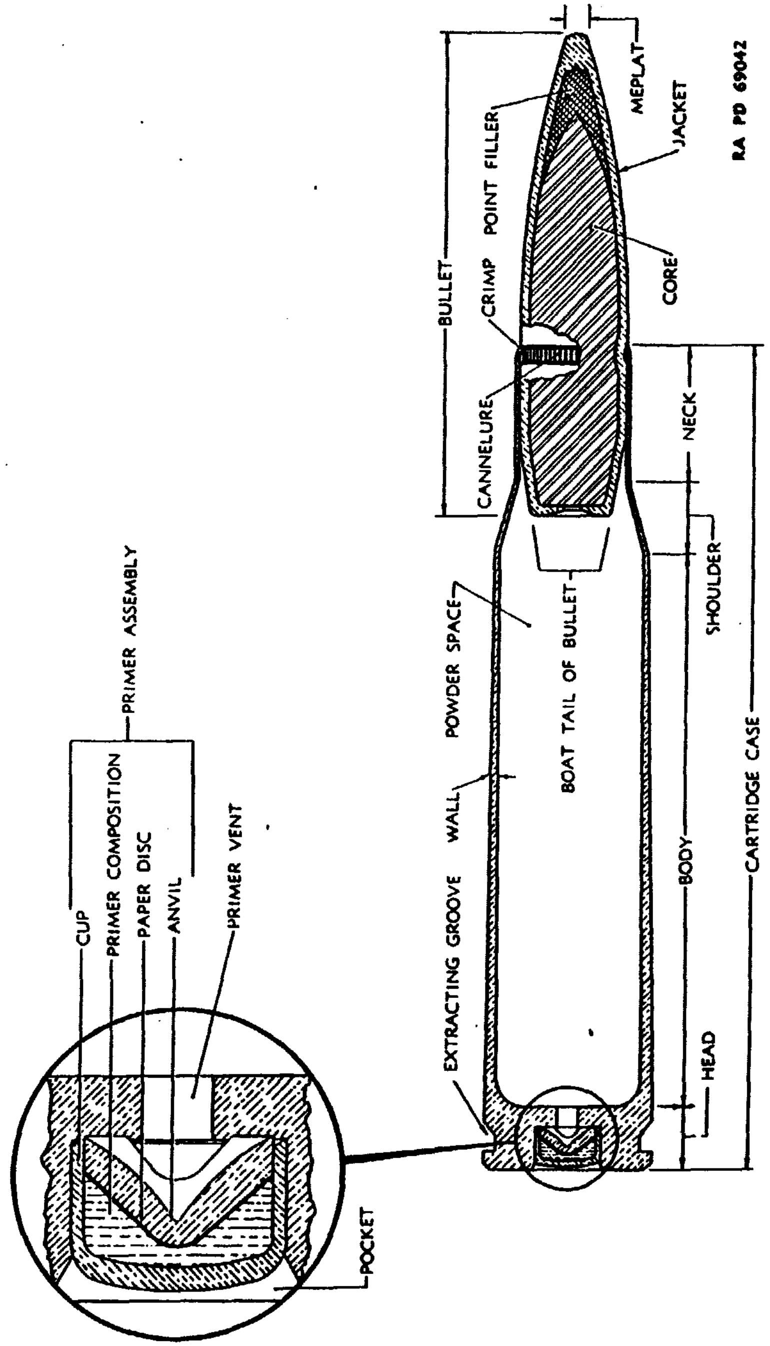
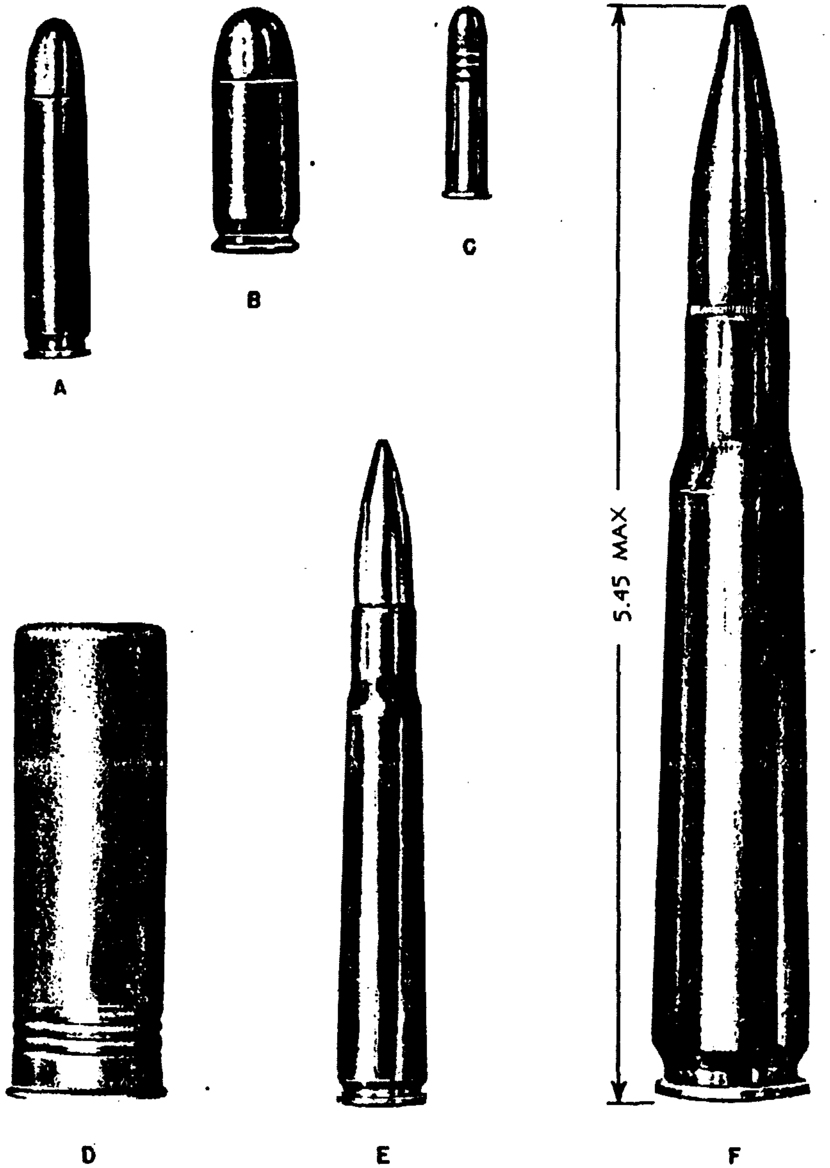


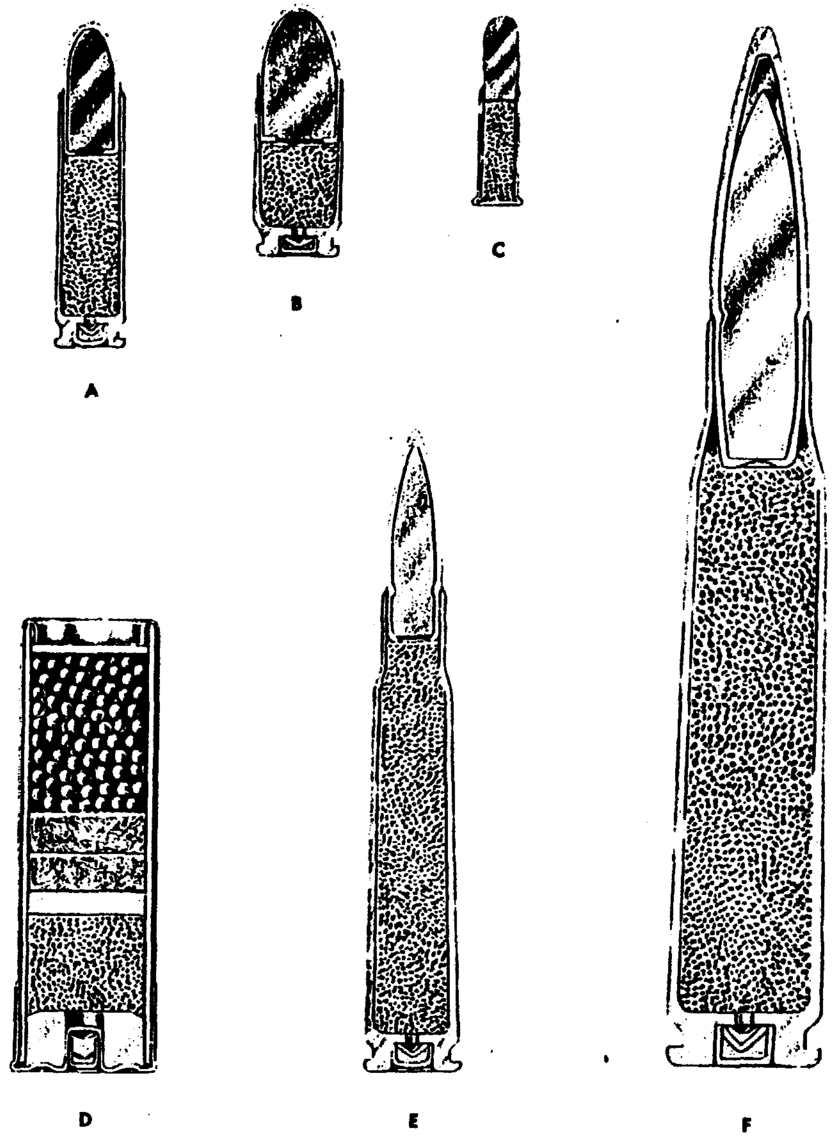
Figure 24 — Cartridge Terminology



A — CAL. .30 CARBINE BALL CARTRIDGE, M1
B — CAL. .45 BALL CARTRIDGE, M1911
C — CAL. .22 LONG RIFLE BALL CARTRIDGE
D — 12-GAGE SHOTGUN SHELL
E — CAL. .30 BALL CARTRIDGE, M2
F — CAL. .50 BALL CARTRIDGE, M2

RA PD 45078

Figure 25 — Types of Small-arms Ammunition

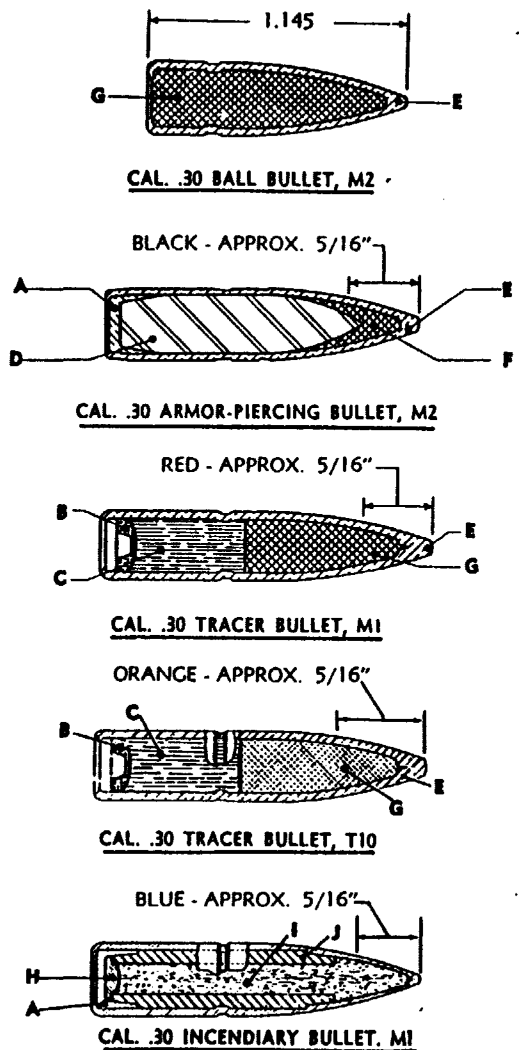


A – CAL. .30 CARBINE BALL CARTRIDGE, M1
B – CAL. .45 BALL CARTRIDGE, M1911
C – CAL. .22 LONG RIFLE BALL CARTRIDGE
D – 12-GAGE SHOTGUN SHELL
E – CAL. .30 BALL CARTRIDGE, M2
F – CAL. .50 BALL CARTRIDGE, M2

RA PD 89561A

Figure 26 — Types of Small-arms Ammunition — Cross Section

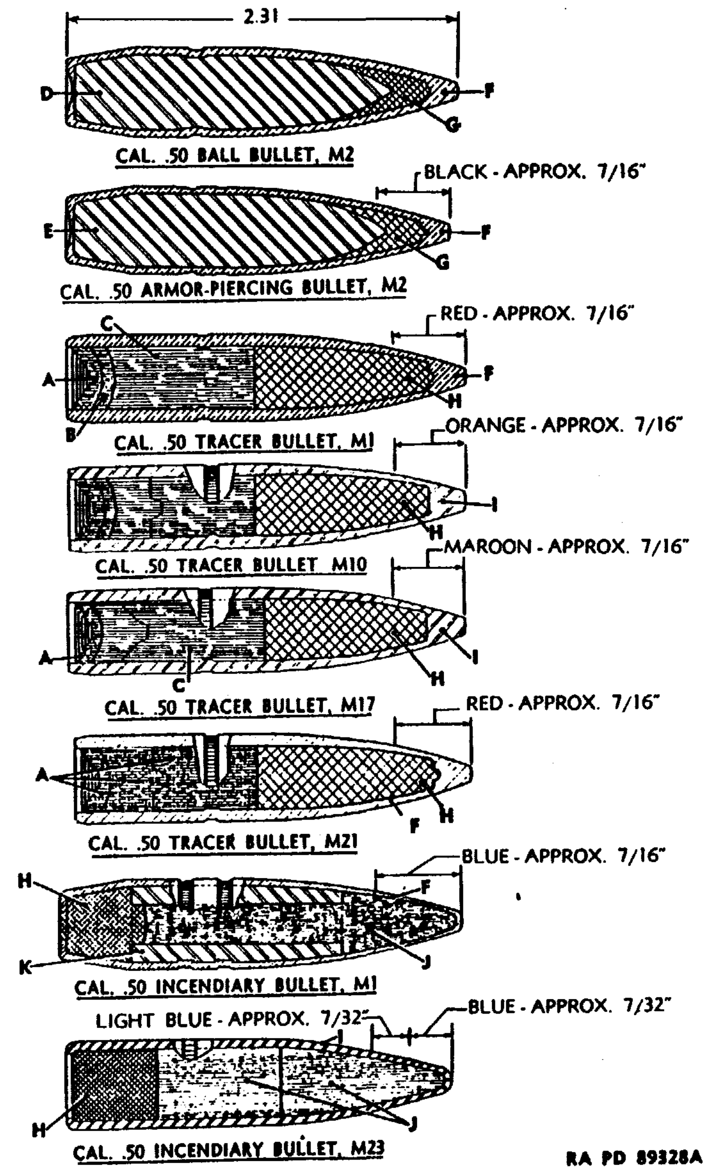
A — BASE, FILLER-GILDING METAL
B — COMPOSITION, IGNITER
C — COMPOSITION, TRACER
D — CORE-TUNGSTEN CHROME STEEL
E — JACKET-GILDING METAL OR GILDING METAL CLAD STEEL
F — POINT FILLER-LEAD "T" SHOT
G — SLUG-LEAD WITH ANTIMONY
H — BODY PLUG-LEAD SHOT
I — INCENDIARY COMPOSITION
J — STEEL BODY



RA PD 4511C

Figure 27 — Caliber .30 Bullets — Cross Section

A — COMPOSITION, IGNITER
B — COMPOSITION, SUB-IGNITER
C — COMPOSITION, TRACER
D — CORE-STEEL
E — CORE-TUNGSTEN CHROME STEEL
F — JACKET-GILDING METAL
G — POINT FILLER-LEAD WITH ANTIMONY
H — SLUG, LEAD WITH ANTIMONY
I — JACKET-GILDING METAL CLAD STEEL
J — INCENDIARY MIXTURE
K — STEEL BODY



RA PD 89328A

Figure 28 — Caliber .50 Bullets — Cross Section

d. **Primer.** The primer consists of a brass or gilding-metal cup which contains a primer-composition pellet of sensitive explosive, a paper disk, and a brass anvil. A blow from the firing pin on the primer cup compresses the primer composition between the cup and the anvil, and causes the composition to explode. The holes or vents in the anvil allow the flame to pass through the primer vent in the cartridge case and ignite the propellant.

e. **Cartridge case.** The cartridge case is made of drawn brass or steel. It serves as a means whereby the other components—primer, propelling charge, and bullet—are assembled into a unit, the cartridge. Another of its functions is to expand and seal the chamber against the escape of gases to the rear when the cartridge is fired. This action is known as obturation. To make the cartridge waterproof and to keep the propelling charge dry, the primer is sealed in the primer seat and the bullet is sealed in the neck of the cartridge case by a thin film of lacquer or varnish at the time of manufacture. An extractor groove, turned in the head of the cartridge case, provides a means of removing the case from the chamber of the weapon.

61. TYPES. Small-arms cartridges are classified according to type as follows:

- Ball
- Armor-piercing
- Armor-piercing-incendiary
- Armor-piercing-incendiary-tracer
- Incendiary
- Tracer
- Blank
- Dummy
- High-pressure test
- Gallery practice
- Guard
- Subcaliber
- Grenade
- Shot
- Shotgun shells

62. BALL. This type of cartridge, intended for use against personnel and light materiel targets, is the oldest service type. It is being replaced for combat purposes, however, by armor-piercing and other types. The term "ball," although no longer accurately describing the shape of the modern bullet, has been continued in use to designate that type of bullet and ammunition used for the same purposes as ammunition of very early design, the bullet of which was actually a ball (figs. 25 to 30). A special high grade of ball ammunition is manufactured each year for the National Matches of that year. The following year it may be used in preliminary firing for such matches. The second year, and thereafter, it is considered as standard service ammunition. The head of each of these cartridges is stamped "N.M." and with the year of manufacture.

63. ARMOR-PIERCING. This type of cartridge is intended for use against armored aircraft and vehicles, concrete shelters, and similar built-resisting targets. The bullet has a hardened steel alloy core. In addition, it may have a base filler and a point filler of a softer metal, such as gilding metal (figs. 27 and 28).

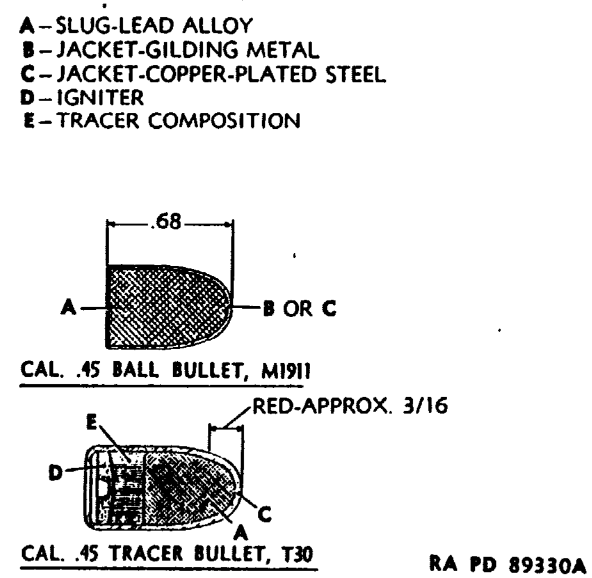


Figure 29 — Caliber .45 Bullets — Cross Section

64. ARMOR-PIERCING-INCENDIARY. This type of cartridge is used in caliber .30 and caliber .50 weapons in lieu of using both armor-piercing and incendiary cartridges.

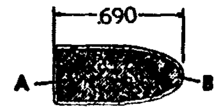
65. ARMOR-PIERCING-INCENDIARY-TRACER. This type of cartridge combines the features of armor-piercing, of incendiary, and of tracer cartridges and is intended to replace these cartridges.

66. INCENDIARY. This type of cartridge is similar to ball or armor-piercing ammunition in outward appearance. It is used for incendiary purposes against aircraft. It contains an incendiary composition, as a central bullet core, which ignites on impact with the target (figs. 27 and 28).

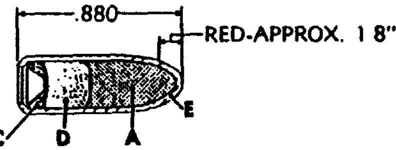
67. TRACER. This type of cartridge is intended for use with other types to show the gunner, by its trace, the path of the bullets, thus assisting in correcting aim. It may also be used for incendiary purposes. The tracer element consists of a pressed inflammable material in the base of the bullet; this composition is ignited by the propelling charge when the cartridge is fired (figs. 27 through 30). For identification, the nose of the bullet is painted red, orange, or maroon.

68. BLANK. This type of cartridge (fig. 31) is distinguished by the absence of a bullet. It is used for simulated fire, training cavalry mounts, and firing salutes. It is also used in machine guns equipped

A–SLUG-LEAD ALLOY
B–JACKET-GILDING METAL
C–IGNITER
D–TRACER COMPOSITION
E–JACKET-GILDING METAL CLAD STEEL



CAL. .30 CARBINE BALL BULLET, M1



CAL. .30 CARBINE TRACER BULLET, M16

RA PD 89332A

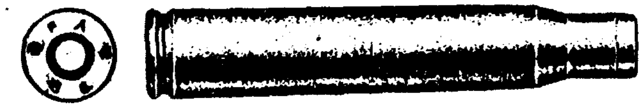
Figure 30 – Carbine Caliber .30 Bullets – Cross Section

with blank-firing attachments in order to operate these weapons for instructional purposes. EC blank powder is used to produce the noise.

69. DUMMY. This type of cartridge (fig. 32) is used for practice in loading weapons, to detect flinching in firing weapons, and to simulate firing. The cartridge case of older lots of dummy ammunition is tin-coated. However, the present means of identification of dummy cartridges is by means of holes drilled through the side of the case and by the empty primer hole. The cartridges are completely inert but simulate service rounds in most details.

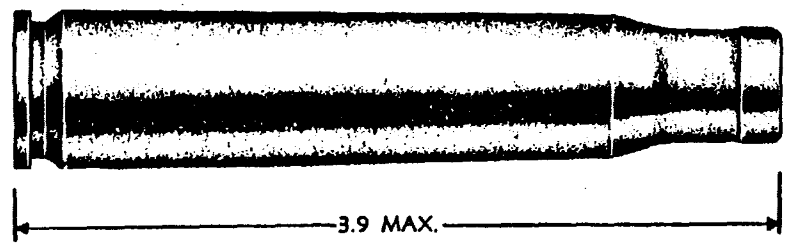
70. HIGH-PRESSURE TEST. This type of cartridge (fig. 33) is manufactured for use in proof firing of small arms. Since the propelling charge of this ammunition develops high pressures, these cartridges should never be used for any other purpose. When used for the purpose intended, all personnel should be protected by adequate cover. This ammunition is distinguished from other types by the tin coating of the cartridge case. In some older lots, the word "TEST" is stamped on the head of the case.

71. GALLERY PRACTICE. The present standard for gallery practice is the caliber .22 long rifle cartridge (figs. 25 and 26), a rim-fire cartridge of commercial manufacture. In the past a gallery practice cartridge, caliber .30 M1919 was used, but any available lots of this cartridge are reserved for guard purposes.



CAL. .30 BLANK CARTRIDGE, M1909

CAL. .45
BLANK CARTRIDGE, M9



CAL. .50 BLANK CARTRIDGE, M1 (M40)

RA PD 89334A

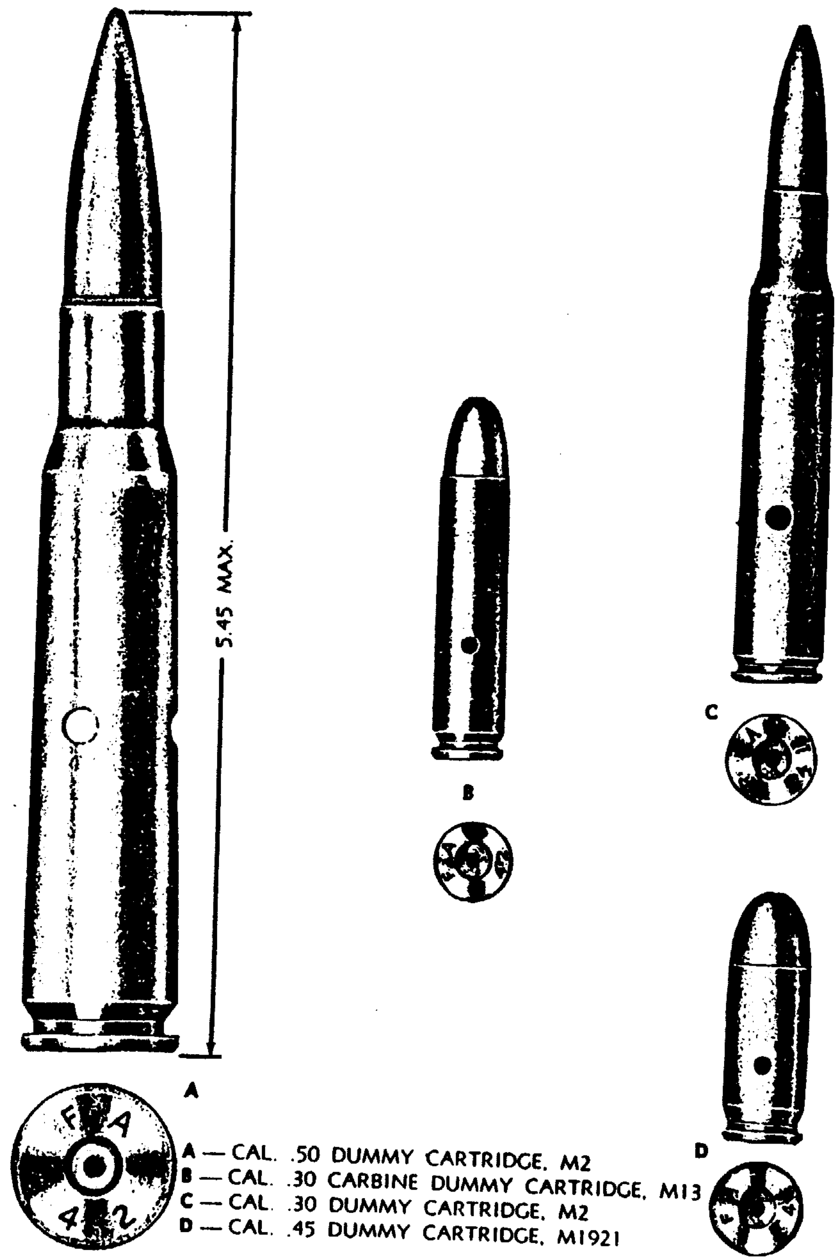
Figure 31 – Blank Cartridges

72. GUARD. Guard cartridges consisted of a low-velocity charge and a round-nose lead bullet together with the cartridge case and primer. The guard cartridge M1 was formerly known as the gallery practice cartridge M1919 (par. 71). As in the case of the gallery practice cartridge, the use of the guard cartridge is being discontinued.

73. SUBCALIBER.

a. This type of cartridge (fig. 34) is fired from subcaliber tubes inserted in larger weapons. The subcaliber cartridge, caliber .30, M1925 is fired from a "Krag" type of subcaliber tube in 3-inch seacoast guns. This cartridge is identified by the extracting rim on the head of the case instead of the usual groove.

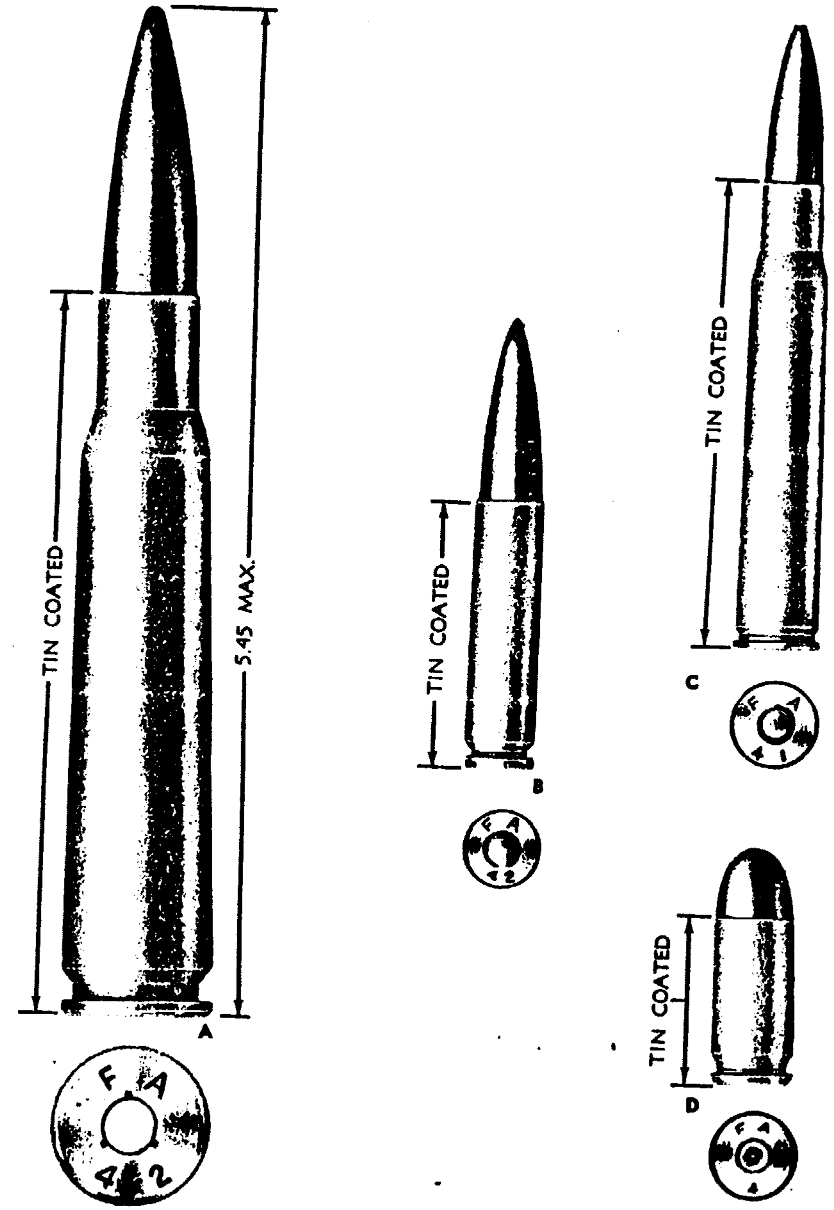
b. Other cartridges, specifically the standard caliber .22, caliber .30, and caliber .50 ball cartridges, are fired from subcaliber tubes in field, tank, and antitank weapons.



A — CAL. .50 DUMMY CARTRIDGE, M2
B — CAL. .30 CARBINE DUMMY CARTRIDGE, M13
C — CAL. .30 DUMMY CARTRIDGE, M2
D — CAL. .45 DUMMY CARTRIDGE, M1921

RA PD 89344A

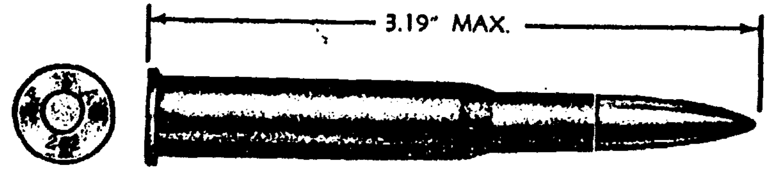
Figure 32 — Dummy Cartridges



A — CAL. .50 HIGH-PRESSURE TEST CARTRIDGE, M1
B — CAL. .30 CARBINE HIGH-PRESSURE TEST CARTRIDGE, M18
C — CAL. .30 HIGH-PRESSURE TEST CARTRIDGE, M1
D — CAL. .45 HIGH-PRESSURE TEST CARTRIDGE, M1

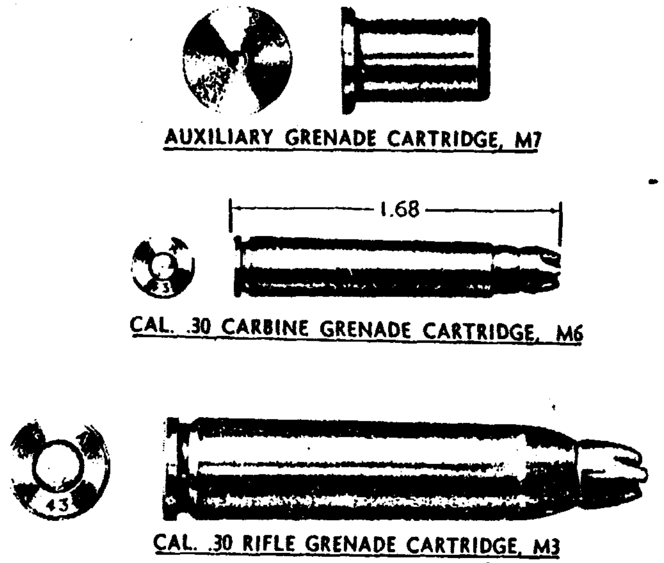
RA PD 89346A

Figure 33 — High-pressure Test Cartridges



RA PD 23078A

Figure 34 — Caliber .30 Subcaliber Cartridge M1925



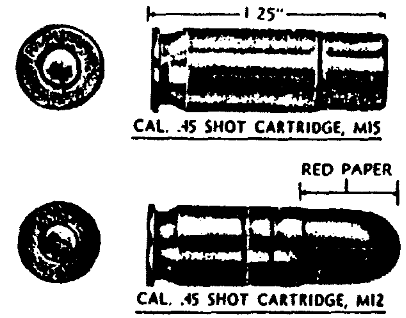
RA PD 68318B

Figure 35 — Grenade Cartridges

74. GRENADE. Grenade cartridges (fig. 35) are special blank cartridges for use in propelling grenades from launchers attached to rifles or carbines. The rifle grenade and carbine grenade cartridges are distinguished by a rose-petal crimp at the mouth of the case. The auxiliary grenade cartridge M7 which contains a propellant but no primer is sometimes used in conjunction with the rifle or carbine grenade cartridge to give additional range.

75. SHOT. Shot cartridges of caliber .45 (fig. 36) are for use in pistols for hunting small game. Instead of a solid bullet, they contain No. 7½ chilled shot, which is also used in shotgun shell loadings. These cartridges are intended primarily for use by air force personnel as an aid in obtaining food.

76. SHOTGUN SHELLS. Shotgun shells (shot shells) of appropriate loads are procured commercially for use in 12-gage sporting-type and riot-type shotguns (fig. 37).



RA PD 89562A

Figure 36 — Caliber .45 Shot Cartridges

77. GRADES.

a. Current grades of existing lots of small-arms ammunition are established by the Chief of Ordnance in accordance with acceptance and surveillance tests, and are published in WD SB 9-AMM 4. Grade 3 indicates unserviceable ammunition, which will not be issued or used.

b. Small-arms ammunition which has been graded "For Training Use Only" will not be used in demonstrations or on training courses requiring this ammunition to be fired over the heads of participating troops.

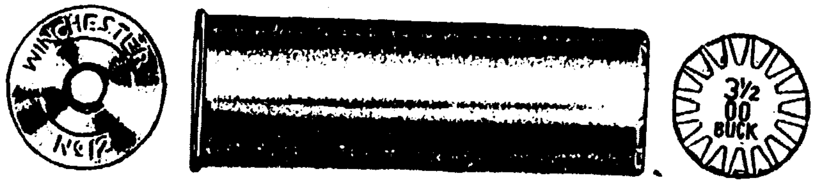
78. CARE AND PRECAUTIONS IN HANDLING.

a. Small-arms ammunition is comparatively safe to handle. However, care must be taken to prevent ammunition boxes from becoming broken or damaged. Broken boxes must be repaired immediately, and careful attention given to the transfer of all markings to the new parts of the box. Metal liners should be air-tested and sealed if equipment for this work is available.

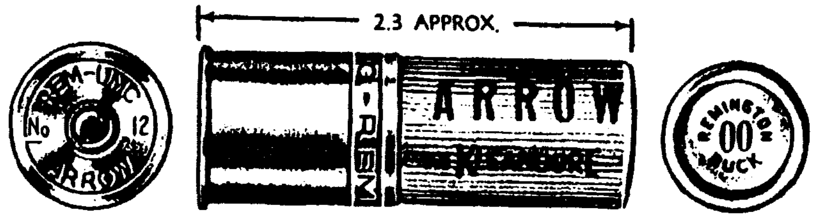
b. Ammunition boxes will not be opened until the ammunition is required for use. Ammunition removed from airtight containers, particularly in damp climates, may corrode and become unserviceable.

c. When cartridges are taken from their original packings for loading into clips or machine gun belts, the clips or belts should be tagged or marked so as to preserve the ammunition lot number, thereby preventing the ammunition from falling into grade 3 through loss of lot number (identity).

d. Ammunition should be carefully protected from mud, sand, dirt, and water. If it gets wet or dirty, it should be wiped off at once.



ALL BRASS NO. 00 BUCK 12-GAGE SHOTGUN SHELL, M19



PAPER #00 BUCKSHOT 12-GAGE SHOTGUN SHELL

PAPER #7-1/2 CHILLED SHOT 12-GAGE SHOTGUN SHELL

PAPER #8 CHILLED SHOT AND TRACER 12-GAGE SHOTGUN SHELL

RA PD 23080A

Figure 37 — Shotgun Shells, 12-gage

If l osion or verdigris forms on cartridges, it should be wiped off. However, cartridges should not be polished merely to make them look brighter or better.

e. Ammunition should not be exposed to the direct rays of the sun for any considerable length of time. This is likely to affect its firing qualities.

f. The use of oil or grease on cartridges is dangerous and is prohibited.

g. Cartridges that are dented, have loose bullets, or are otherwise defective should not be fired.

79. PRECAUTIONS IN FIRING.

a. Because a misfire cannot immediately be distinguished from a hangfire, it is unsafe to open the bolt of a rifle for at least 10 to 15 seconds after a misfire occurs. When the rifle M1 fails to fire, it should be recocked by means of the trigger guard and refired before the bolt is opened. When the rifle M1903 fails to fire, it should be recocked by drawing back the cocking piece and should be refired before the bolt is opened. The rifle M1917 cannot be recocked without opening the bolt; in case of misfire, wait a full minute before the bolt is opened. When the caliber .30 carbine fails to fire, pull the operating slide to the rear and release the operating rod. If the operating slide goes fully home, aim and fire. To avoid injury in case of hangfire, hold the hand so that no part of the palm or wrist can be struck by the operating slide in its rapid rearward movement.

b. Before firing, be sure that the bore of the weapon is free of any foreign matter such as cleaning patches, mud, sand, snow, etc. Firing a weapon with any obstruction in the bore will result in damage to the weapon and may result in injury to the firer.

c. No small-arms ammunition will be fired until it has been identified positively by ammunition lot number and grade, as published in the latest revision of WD SB 9-AMM 4.

d. For precautions in firing blank ammunition, see TM 9-1990.

e. Any serious malfunction of ammunition must be reported promptly to the ordnance officer under whose supervision the material is maintained and issued. As provided in AR 750-10, the ordnance officer will report such malfunction to the Chief of Ordnance. It is important, therefore, that all evidence be preserved. This includes the cartridge case, other cartridges from the same box, the weapon concerned, and all recoverable pieces—in short, everything that might determine the cause of the malfunction.

80. PACKING AND MARKING.

a. **Packing.** Dependent on its intended use, small-arms ammunition is packed in link and web belts, clips, or cartons (figs. 38

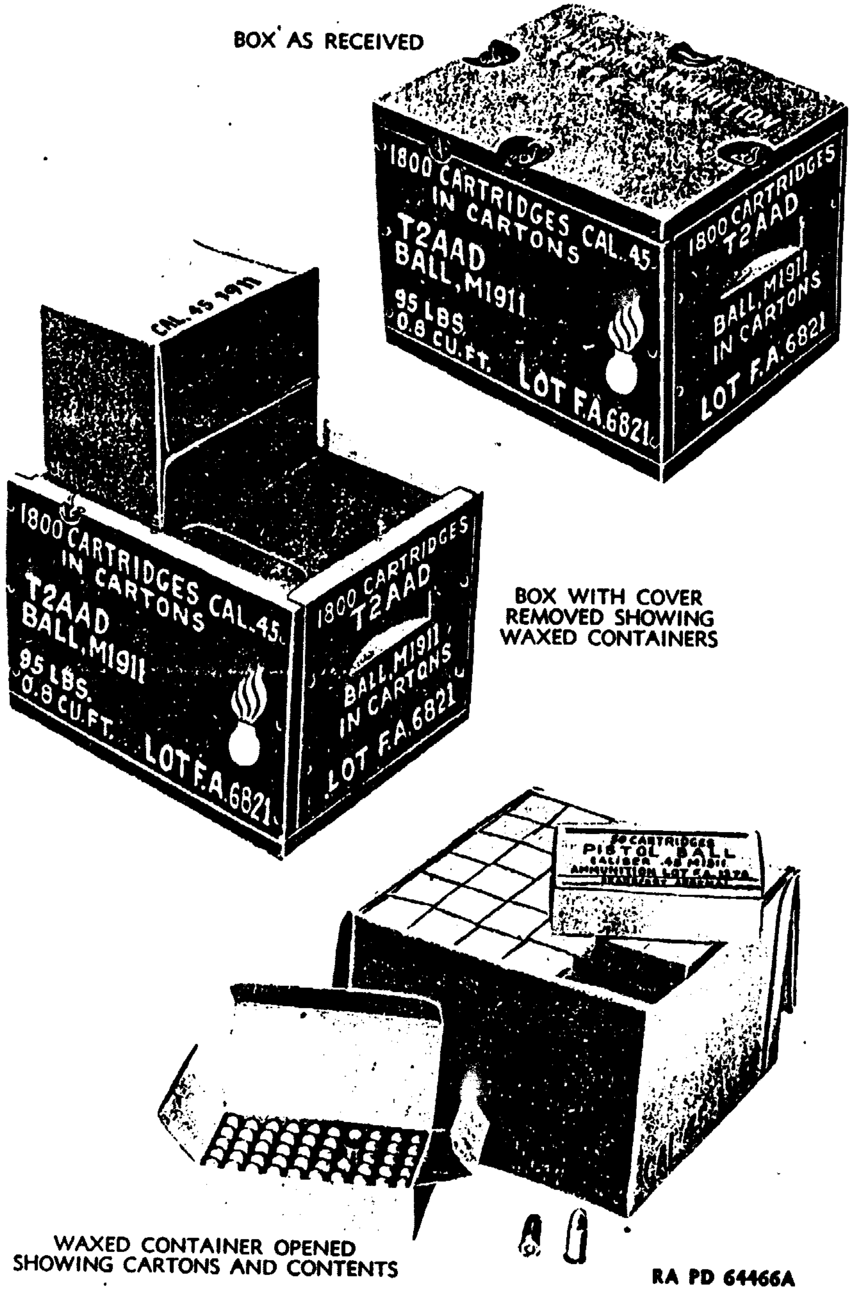


Figure 38 – Boxes Containing Carton-packed Ammunition in Waxed Containers

Figure 39 – Boxes Containing Carton-packed Ammunition in Metal Cans

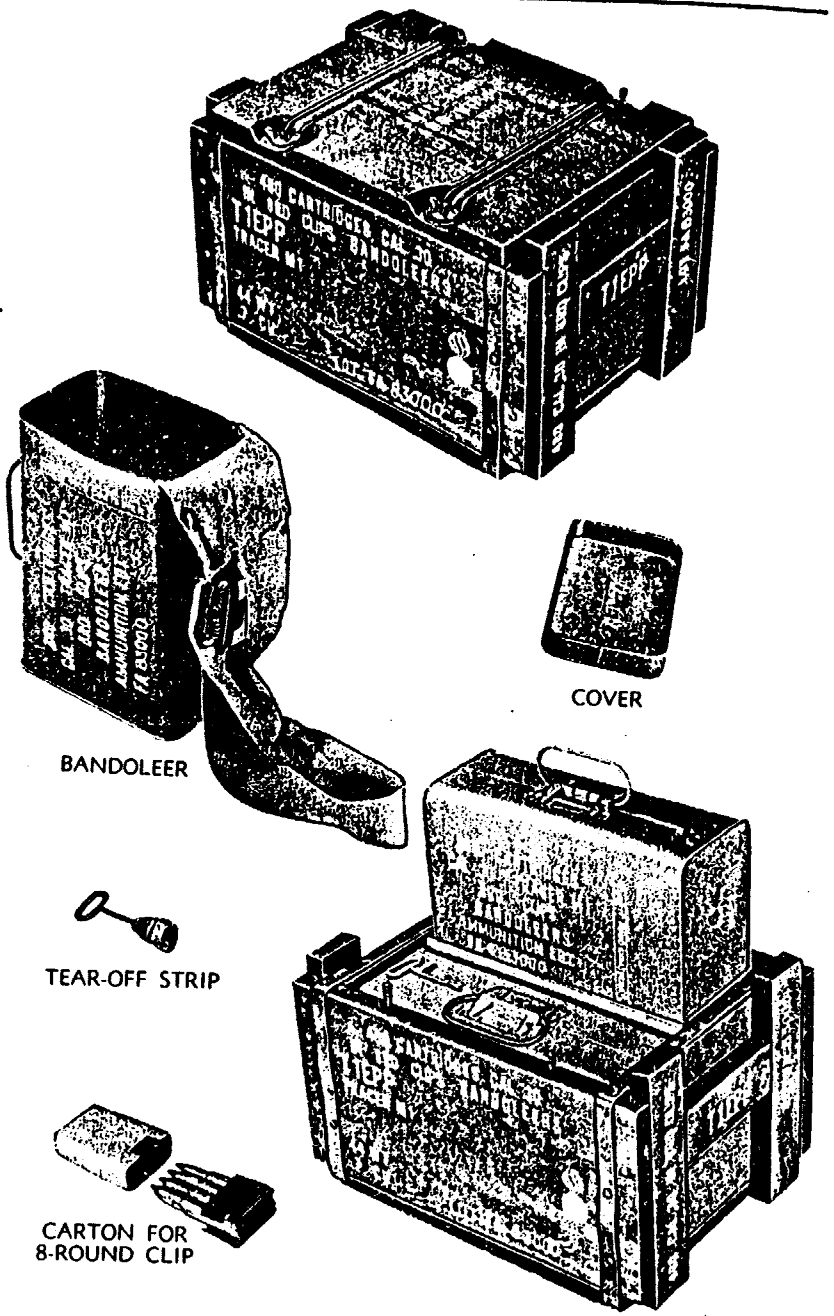


Figure 40 — Boxes Containing 8-round Clipped Ammunition in Bandoleers in Metal Cans

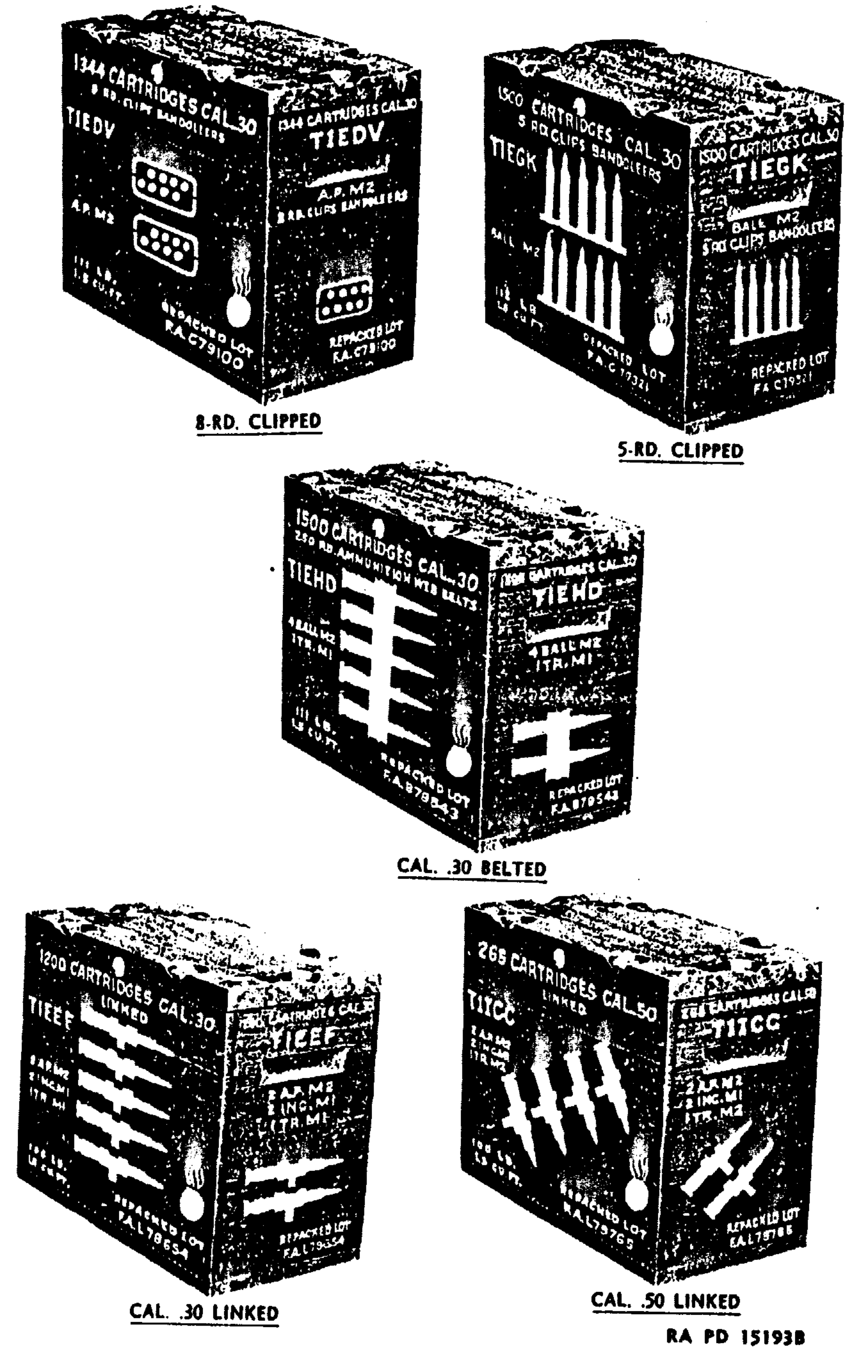
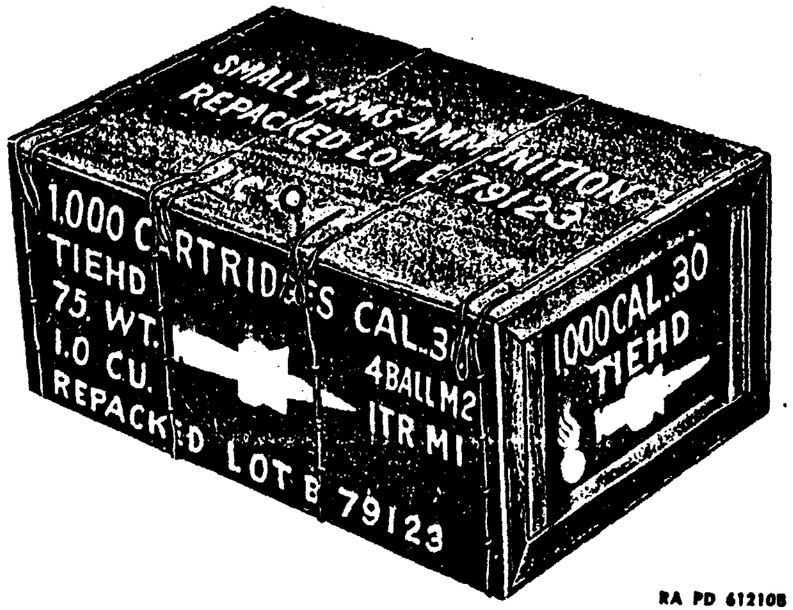
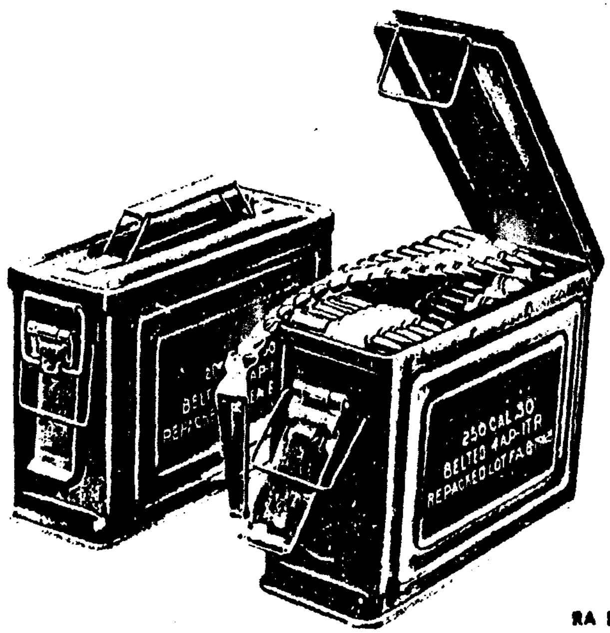


Figure 41 — Packing Symbols on Small-arms Ammunition Boxes



RA PD 612108

Figure 42 — Wire-bound Crate for Four Ammunition Boxes, Cal. .30, M1



RA PD 683198

Figure 43 — Ammunition Box, Cal. .30, M1 (Steel)

through 43). For example, ammunition intended for use in the rifle M1 is packed in 8-round clips. For a detailed description of packing, see ORD 11 SNL's of the T group.

b. Marking.

(1) Small-arms packing boxes may be either stained brown with marking in yellow, or unstained with marking in black. Markings for shipment are covered in chapter 3, section IV, and in TM 9-1990.

(2) Instead of the lot number, a repacked lot number may be stenciled on packing boxes containing web belts and metallic link belts; the serial number of the repacked lot number is preceded by the letter "B" for belted ammunition, and "L" for linked cartridges.

(3) To provide a further means of quickly identifying type of packing, stenciled figure silhouettes are used on boxes and crates containing clipped, belted, and linked cartridges. These symbols indicate whether the ammunition is packed in rifle clips, web belts, or linked belts. The silhouettes are vertical for caliber .30 cartridges, and diagonal for caliber .50 cartridges (fig. 41). The absence of stenciled figure silhouettes on boxes indicates carton-packed ammunition (figs. 38 and 39).

(4) The expendable metal ammunition boxes are painted olive-drab with marking in yellow (fig. 43).

Section II

GRENADES

81. GENERAL DESCRIPTION.

a. Definition. Grenades are small explosive or chemical missiles intended for use against an enemy at relatively short ranges.

b. Basic types. There are two basic types of grenades—those intended to be thrown by hand (figs. 11 and 44) and those intended to be projected from rifles or carbines equipped with suitable grenade launchers (figs. 12 and 45). By attaching a suitable adapter, some of the hand grenades may also be fired from rifles and carbines (figs. 46 and 47). Hand grenades provide the soldier with an auxiliary weapon, similar to a shell or bomb, to supplement his basic weapons. Rifle grenades are valuable not only for specialized use, such as against tanks, but also for covering the ranges between the maximum for hand grenades and the minimum for mortar shell. Special blank cartridges (fig. 35), packed with the rifle grenades, must be used in the weapon for projecting these grenades.

c. General types. Both hand and rifle grenades can be classified into three general types, namely: explosive, chemical, and practice or training.

(1) Explosive grenades are used primarily for antipersonnel (fragmentation or blast) or antitank effect. They may also be used as demolition agents.

(2) Chemical grenades are used for casualty, harassing, incendiary, screening, and signaling purposes. Some of them may also be used for training purposes and destruction.

(3) Practice and training grenades are used in training troops for combat.

d. Fuzing. Grenades thrown by hand are normally fitted with a delay-action fuze. For explosive hand grenades and the chemical M15 (bursting type) WP smoke hand grenade, this delay is set for approximately 4.5 seconds. Burning-type chemical hand grenades use a fuze with a delay of approximately 2 seconds. Rifle grenades are usually fitted with a base fuze that functions on impact.

82. EXPLOSIVE HAND GRENADES.

a. Fragmentation type. The Mk 2 is a typical fragmentation hand grenade (fig. 11 and A, fig. 44). This grenade is made of cast iron varying in thickness from ⅛ to ¼ inch. The body is lemon-shaped, approximately 2¼ inches in diameter and 3½ inches in length without the fuze. It contains an explosive charge which, upon detonation, breaks up the body of the grenade and fuze and projects the fragments outwards in all directions at high velocity. The body is grooved both horizontally and vertically. The fuze for this grenade has a primer, a combustible time-delay train, and a detonator. Attached to the fuze body is a safety lever held in place against the action of the striker spring by means of a safety pin. Just prior to throwing, the safety pin is removed. When the grenade is thrown, the safety lever is pushed off by the striker, allowing the striker to impact against the primer. The primer ignites the time-delay train and, after 4 or 5 seconds, this delay train causes the detonator to explode. This, in turn, causes the explosive filler in the grenade to detonate, thereby fragmenting the grenade. Fragments may fly over 200 yards.

b. Offensive type. The offensive grenade (fig. 11 and C, fig. 44) is intended to have an antipersonnel effect over a small area. It contains more explosive than the fragmentation-type grenade, approximately ½ pound of pressed TNT, and, therefore, is more useful as a demolition agent. No fragmentation effect is obtained.

83. CHEMICAL HAND GRENADES.

a. Burning type. The standard container for this type of grenade (fig. 11 and D, fig. 44) is a cylindrical steel can 2⅜ inches in diameter and 4¾ inches high. The fuze for these grenades is similar to the fuze used in the Mk 2 fragmentation grenade, except that it

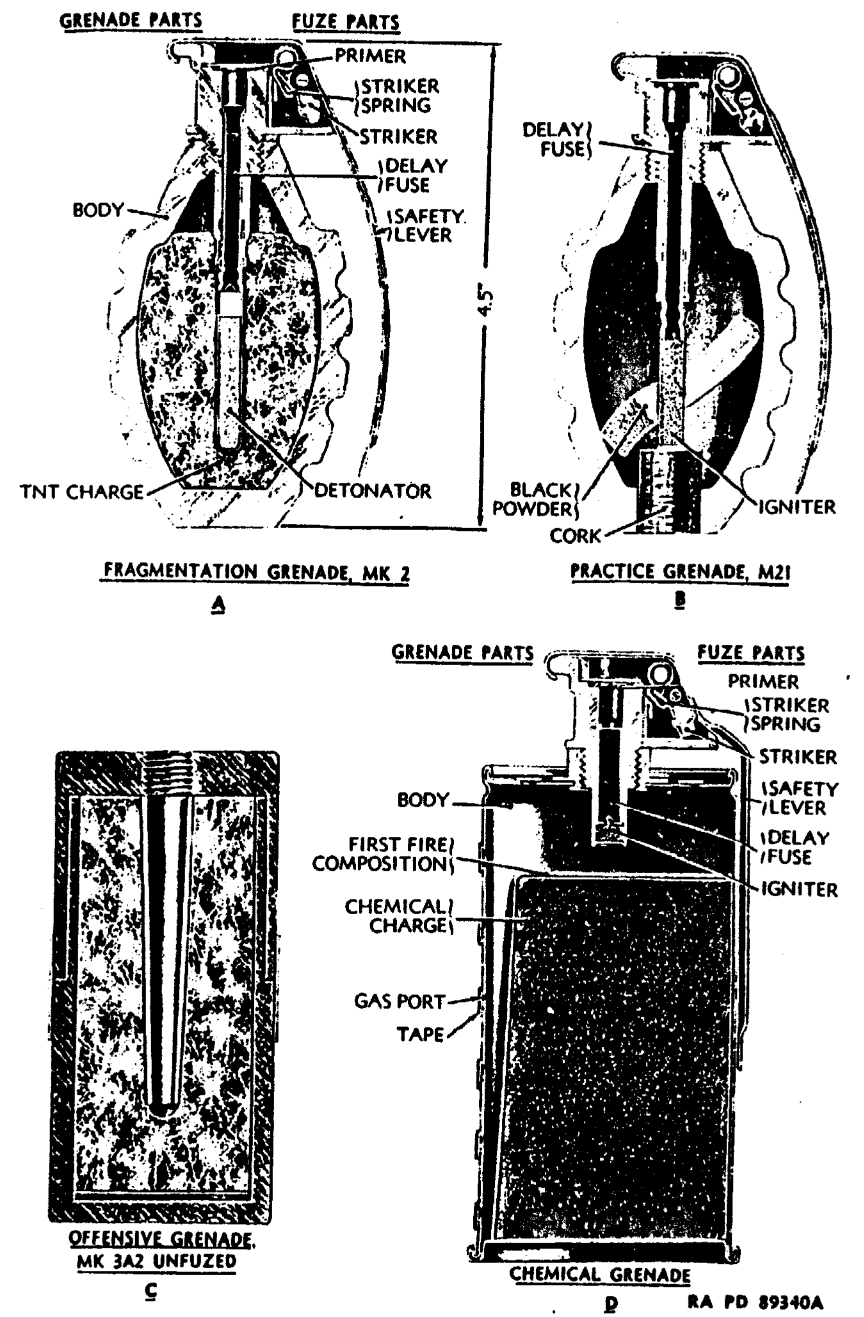


Figure 44 — Hand Grenades — Cross Section

has an igniter instead of a detonator, and has a short delay time of 2 seconds. Grenades of this type have waterproof, adhesive-tape covered, smoke emission holes in the top, sides, or bottom. These grenades are described briefly as follows:

(1) CN-DM IRRITANT HAND GRENADE. The products of combustion of the filler in this grenade have a harassing effect. Its principal use is in the control of civil disturbances. The burning time is 20 to 60 seconds. The filler is a composition of tear gas, vomit gas, and smokeless powder.

(2) CN TEAR HAND GRENADE. This grenade is identical with the CN-DM grenade except that it has a tear gas filler. Principal uses are in control of civil disturbances, and training in use of the gas mask.

(3) HC SMOKE GRENADE. This is an Army-Navy standard white smoke grenade, used for signaling and screening purposes. The container is standard except that there are no emission holes in the side. The burning time is 2 to 2½ minutes.

(4) TH INCENDIARY GRENADE. This is an Army-Navy standard munition for setting fire to enemy materiel. The container is standard except that there are no emission holes in the side. Clamps of steel strapping, which fit around the body of the grenade, may be used to nail the grenade against an object to be burned. The filling is thermate, which burns at approximately 4,330° F for 30 to 35 seconds.

(5) COLORED SMOKE GRENADE M16. This grenade, used for ground-air and ground-ground signaling purposes is made in the following colors: green, yellow, red, and violet. It is of standard construction and burns for approximately 2 minutes.

(6) COLORED SMOKE GRENADE M18. This grenade, available in red, green, yellow, and violet, is also used for signaling purposes. The container has emission holes in the top, and a single hole at the bottom. A tapered hole extends through the center of the grenade from the bottom emission hole to the fuze. The starter mixture lines the tapered cavity. The grenade produces a heavy smoke for approximately 1 minute.

(7) RED SMOKE GRENADE AN-M3. This grenade is an Army-Navy air forces official distress signal. It is the standard metal grenade except that the fuze lever is shortened and the body is covered with a metal jacket to which are attached three metal strips which may be bent out from the jacket to keep the grenade from sinking into snow or soft ground. Burning time is 2 to 2½ minutes.

b. Bursting type. There is only one standard chemical grenade of this type and it is known as the WP smoke grenade M15. This grenade has a drawn-steel cylindrical body similar in size to the burning-type chemical hand grenades, and is filled with white phos-

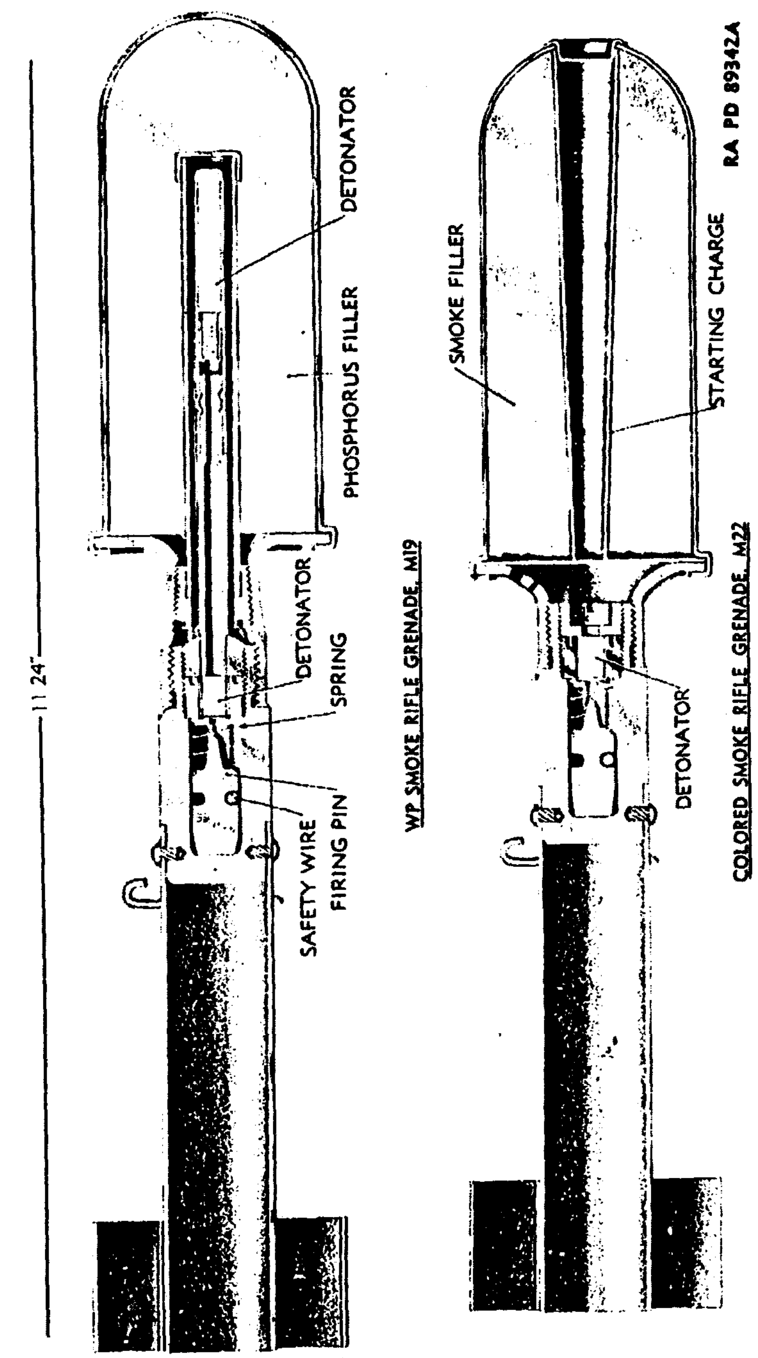


Figure 45 — Smoke Rifle Grenades — Cross Section

phorus. The detonating fuze used in this grenade causes it to split open and project burning particles of phosphorus over a radius of about 15 yards. This produces a dense white smoke screen and will cause casualties by burning.

84. PRACTICE AND TRAINING HAND GRENADES. This type of grenade (fig. 11 and B, fig. 44) is used in training. They may be inert (training), or loaded with a charge of black powder contained in a cloth tube (practice). In this case the charge is inserted into the filling hole, which is closed with a cork.

85. EXPLOSIVE RIFLE GRENADES. Antitank type: A typical antitank rifle grenade, the M9A1 (fig. 12) consists of a sheet-steel body, cone, and ogive assembly to which is attached a simple base-detonating fuze and a stabilizer and fin assembly. The head of the grenade contains a 4-ounce cast-pentolite, shaped charge for blasting holes in the target. At the same time detonation of the main charge causes fragmentation of the body in a lateral direction. The grenade is intended primarily for use against armored vehicles. It has been found to be most effective against enemy personnel when it is fired at a high angle of elevation (45°).

86. CHEMICAL RIFLE GRENADES.

a. **Burning type.** These grenades consist of a deep-drawn, thin-walled steel body with hemispherical ogive and body union assembly to which is attached a simple base fuze and a stabilizer and fin assembly (B, fig. 30). This type of grenade is available with approximately 10¾ ounces of HC white smoke or 6½ ounces of standard colored smoke fillings. Both HC and colored smoke grenades have five sealed smoke emission holes in the body union. The colored smoke grenades also have a smoke emission hole in the ogive. Both of these types of chemical rifle grenades commence burning upon impact, due to the action of the base initiating type of fuze. The HC grenade is intended primarily for screening purposes and the colored smoke grenades for signaling.

b. **Bursting type.** This grenade is the counterpart of the WP smoke hand grenade M15. The WP smoke rifle grenade M19 (A, fig. 45) has a stabilizer and fin assembly identical to that used in the antitank grenade M9A1. It contains approximately 8.5 ounces of white phosphorus and is equipped with a burster actuated by a base-detonating fuze. The spontaneously combustible WP grenade is scattered upon impact.

87. PRACTICE AND TRAINING RIFLE GRENADE. There is at present only one standard practice rifle grenade, the M11A3 (fig. 12). This grenade is used only in training and simulates the flight and

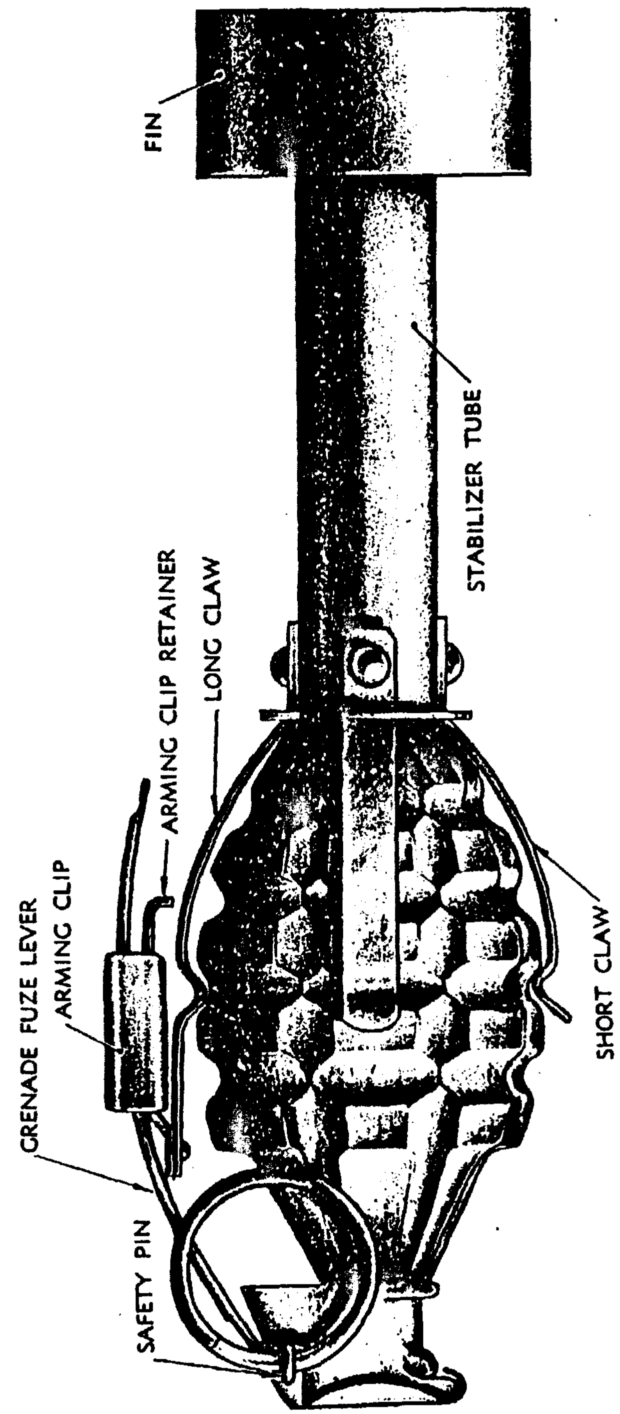


Figure 46 — Fragmentation Grenade Projection Adapter M1

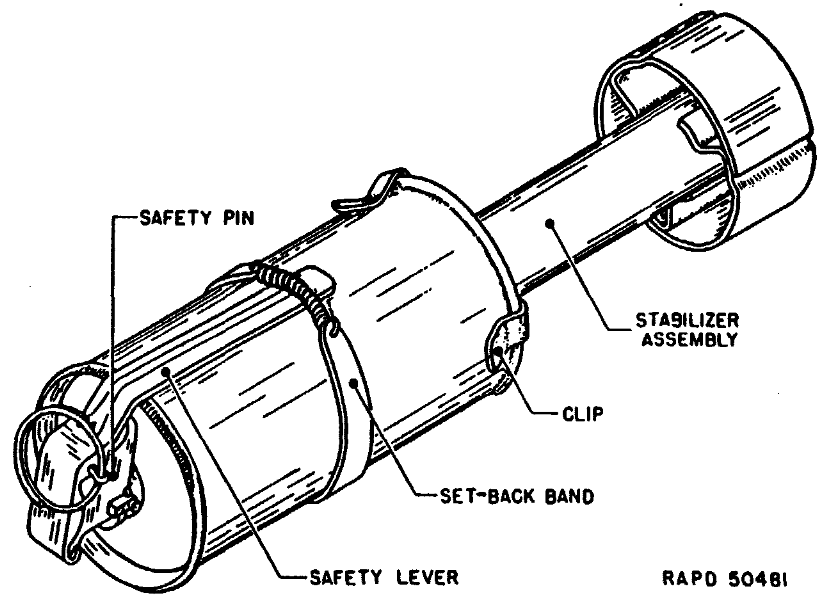


Figure 47 – Chemical Grenade Projection Adapter M2

action of the AT grenade M9A1. Being completely inert, this grenade is painted black. For repeated use, it is issued with additional replacement fins and ogives.

88. GRENADE PROJECTION ADAPTERS.

a. The grenade projection adapter (fig. 46) assembled to a fragmentation hand grenade Mk 2 permits this hand grenade to be used as a rifle grenade. After removal of the grenade safety pin before firing, the safety lever is held in position by the arming clip. Upon firing the grenade from a launcher-equipped rifle or carbine, the arming clip frees itself from the arming clip retainer, thereby releasing the grenade safety lever and initiating the 5-second fuze. Grenade cartridges are packed in each adapter packing box.

b. The chemical grenade-projection adapter (fig. 47) is intended for use with the chemical hand grenades. It consists of a stabilizer tube, which has a base plate and a three-pronged clip on one end and on the other end, a standard fin similar to that on the grenade M9A1, and a metal setback band which fits around the grenade, over the safety lever. Upon firing the grenade from a launcher-equipped rifle or carbine, the setback band moves to the rear, thereby releasing the grenade safety lever and initiating the 2-second fuze. Grenade cartridges are packed in each adapter cartridge packing box.

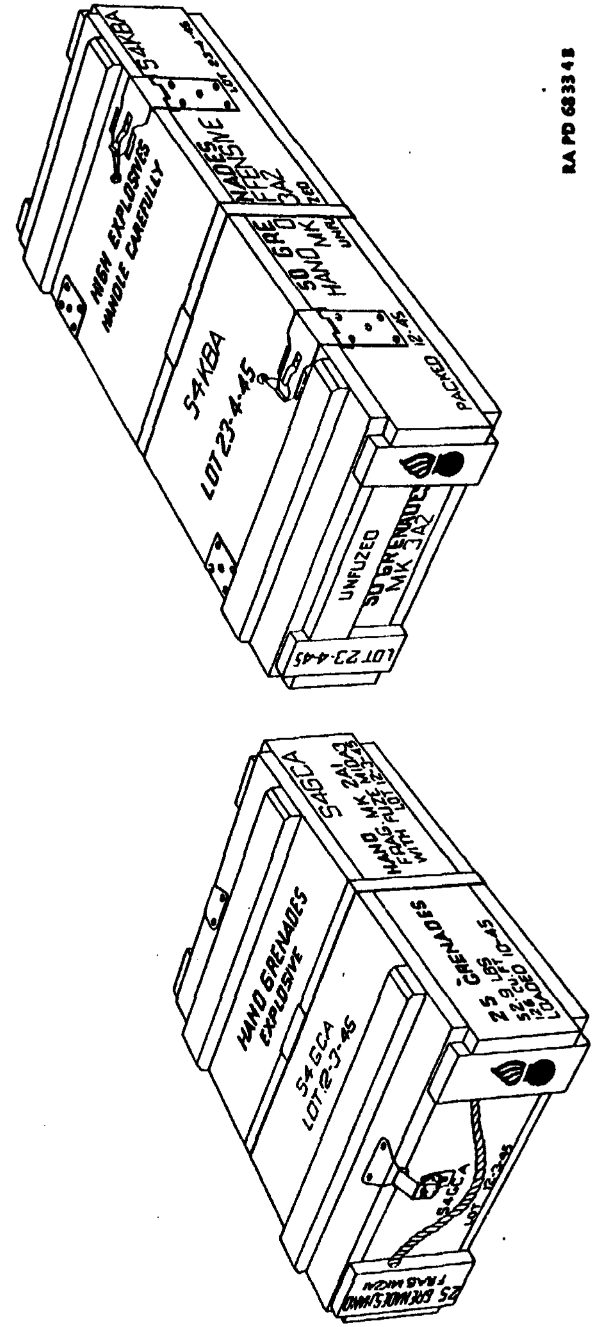


Figure 48 – Typical Packing of Hand Grenades

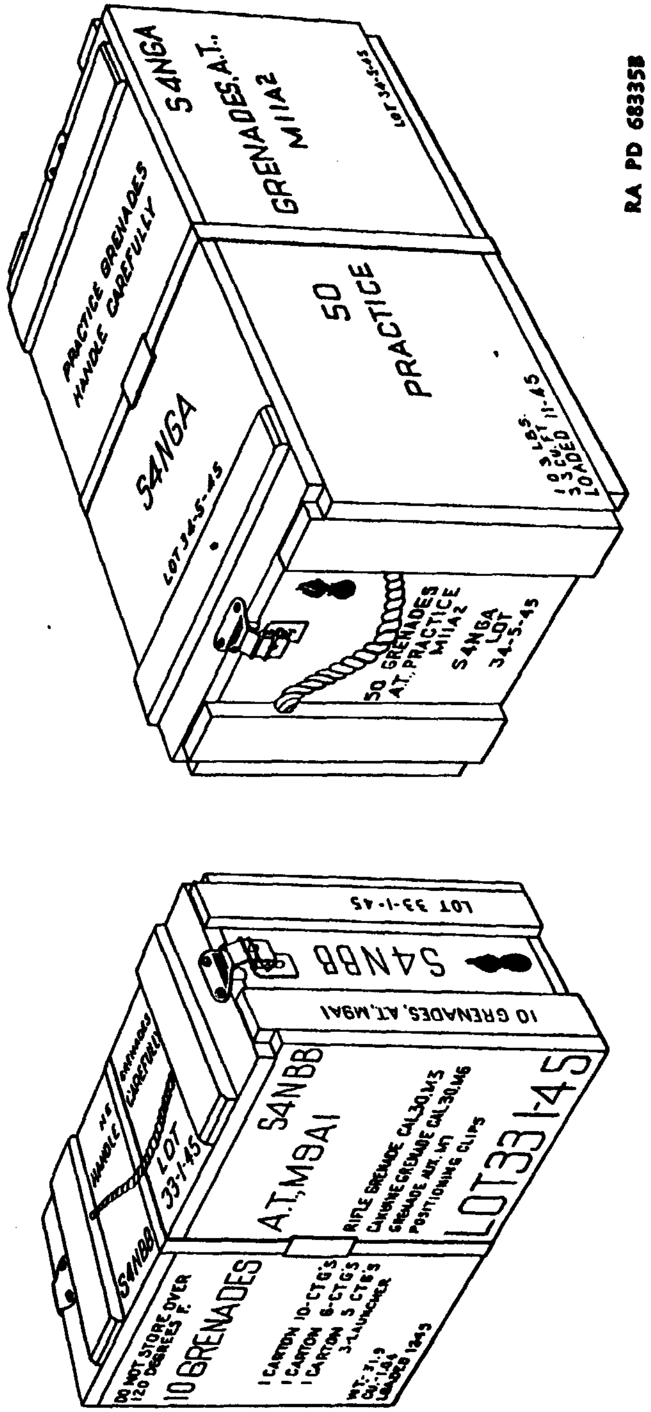


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Figure 49 — Typical Packing of Rifle Grenades

89. CARE AND PRECAUTIONS IN HANDLING.

a. Care. Information concerning the care to be exercised in handling grenades will be found in chapter 3 of this manual and pertinent Field Manuals.

b. Precautions. The following additional safety precautions for handling ammunition will also be observed:

(1) Since fragments may be projected over 200 yards, fragmentation grenades will not be used in training without adequate cover.

(2) The safety pin will be removed just before throwing or launching and at no other time.

(3) Occasionally, chemical grenades may flash. Hence, when used in maneuvers, they will be so thrown as to function not less than 30 feet from personnel.

(4) Duds will be disposed of in accordance with the provisions in chapter 4.

(5) *Rifle grenades must never be launched with a cartridge other than the special grenade cartridges provided for that purpose.*

(6) The fuze furnished with the grenade Mk 2 is noiseless, smokeless, and sparkless. Under no condition, therefore, will the thrower consider the grenade a dud because no noise, smoke, or sparks are observed upon release of the safety lever.

90. IDENTIFICATION. High-explosive grenades are painted olive-drab with yellow bands around the top of the grenade body. Training hand grenades (inert) are painted black; practice grenades containing a simulated charge are painted blue. Practice rifle grenades are painted black with white stenciling. Chemical grenades are painted blue-gray with identification band and marking in the appropriate color as indicated in chapter 1, section II and in figures 11 and 12. The stabilizer assembly of all rifle grenades is painted olive-drab.

91. PACKING.

a. Grenades are usually packed as fuzed complete rounds, each in an individual fiber container.

b. Fragmentation grenades are packed 15 or 25 containers per wooden box.

c. The offensive hand grenades are packed 50 per wooden box (fig. 48), and the training grenades are packed 24 per box.

d. The standard packing for rifle grenades is 10 containers per box (fig. 49), with a supply of cartridges for launching from any appropriate weapon. Jungle packing is waterproofed to withstand hot humid climates.

e. Grenade-projection adapters are packed 48 per box, with sufficient number of various grenade cartridges and positioning clips.

Section III

MORTAR AMMUNITION

92. DESCRIPTION.

a. To obtain maximum accuracy and range, projectiles for smooth-bore mortars are stabilized by means of fins assembled to a shaft which is secured to the base end of the projectile; when the fins are omitted, the projectile tends to tumble and be erratic in flight.

b. In general, the ammunition has an adjustable propelling charge, consisting of a number of propellent increments, usually sealed in individual cellophane bags, and an ignition cartridge, to permit firing various ranges or zones of fire. The propellent increments are attached to the fin shaft or within the fin blades; the ignition cartridge is inserted in base end of the fin shaft.

c. The primer and ignition cartridge are separate elements. The primer is screwed into the shaft after the ignition cartridge has been inserted. The assembly of the ignition cartridge and the propellent increments make up the required propelling charge; or the ignition cartridges alone may be used for very short range in the 60-mm mortar and with the light-weight round (M43A1) in the 81-mm mortar.

d. Because the complete round (figs. 50 and 51) is loaded into the mortar as a unit and provision is made for adjusting the propelling charge, ammunition of this type comes within the classification of semifixed ammunition.

93. CLASSIFICATION.

a. According to the purpose for which it is intended, mortar ammunition is classified as high-explosive, smoke, illuminating, practice, or training.

b. High-explosive mortar shell are used for fragmentation or demolition effect, according to the action of the fuze and design of shell.

c. Smoke shell contain chemical fillers.

d. Illuminating shell are intended for signaling and illuminating purposes.

e. Practice shell may have a spotting charge or may be inert.

f. Training projectiles are provided for training and practice. They are inert and may be fired more than once. Several propelling charges and fins are supplied for each projectile.

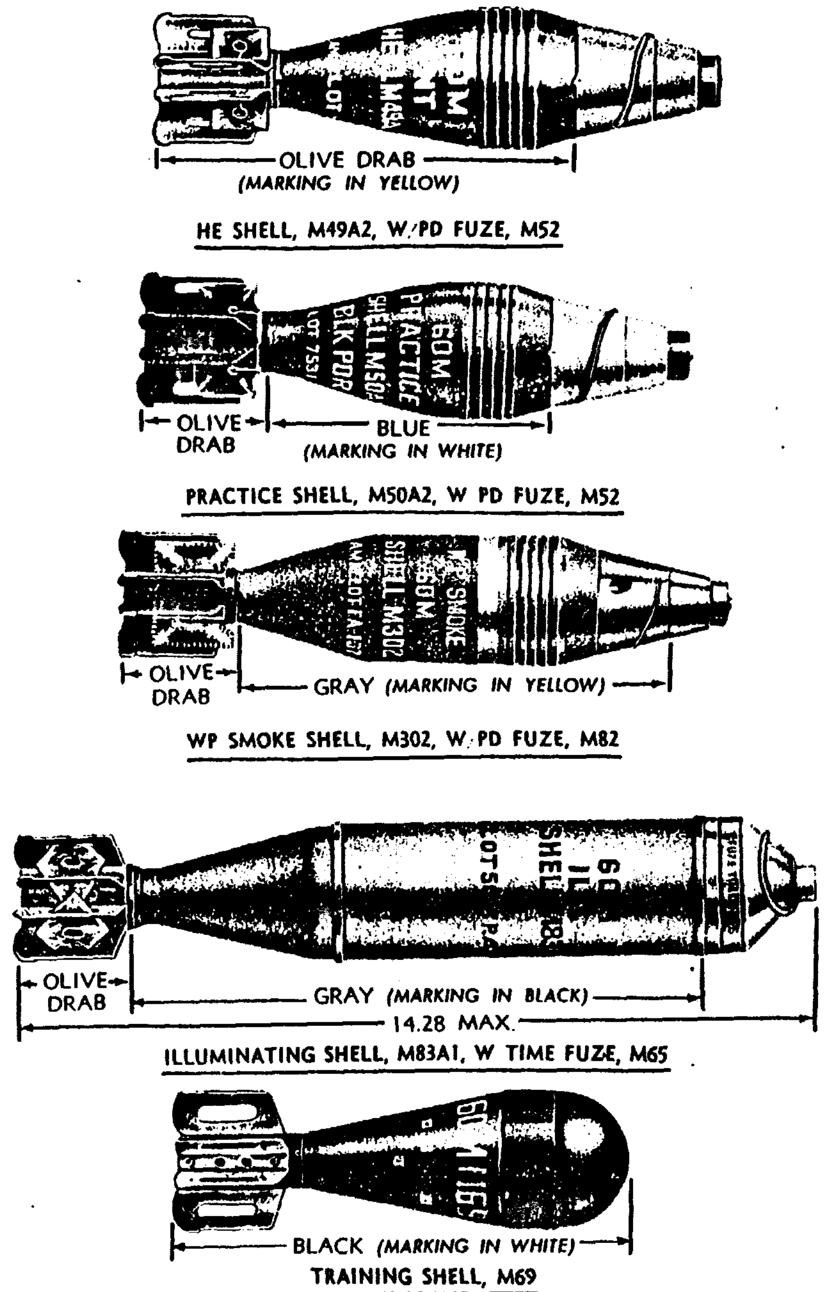

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Figure 50 — 60-mm Mortar Ammunition

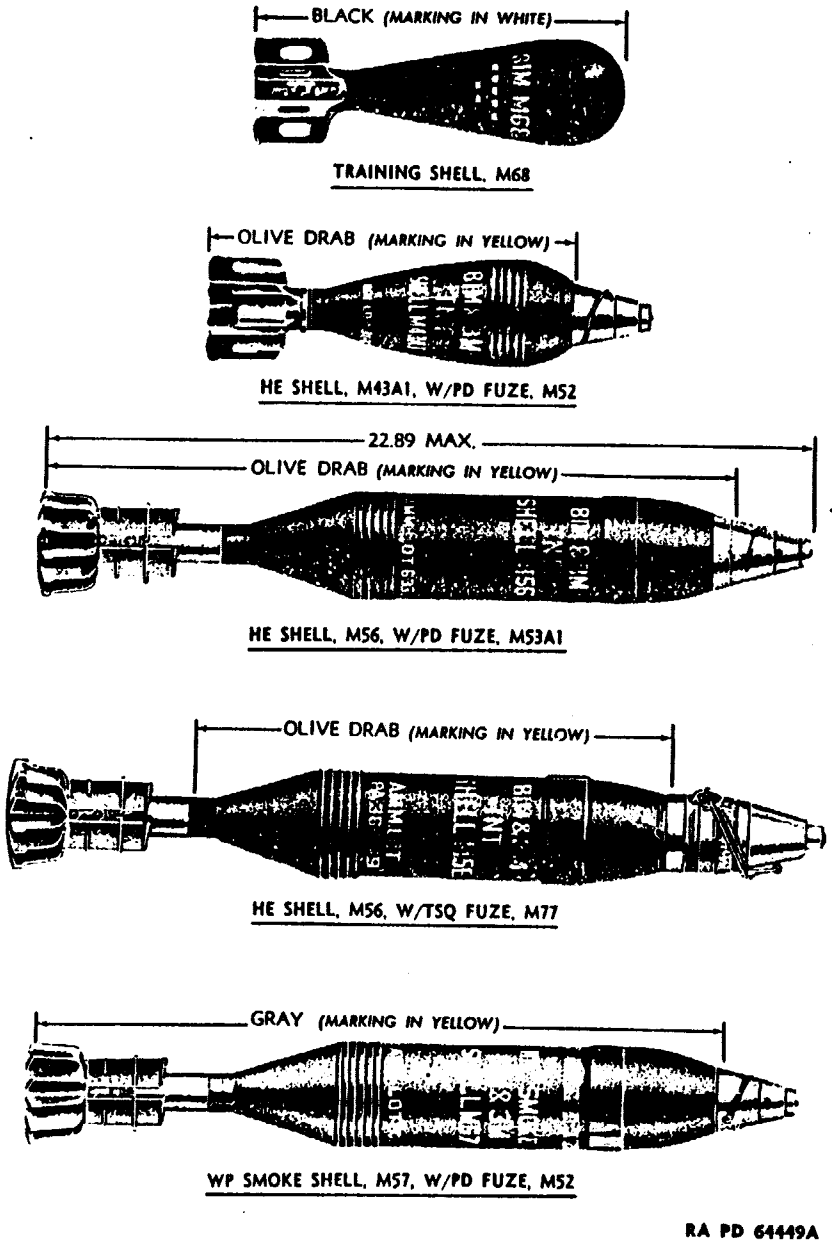

Figure 51 — 81-mm Mortar Ammunition

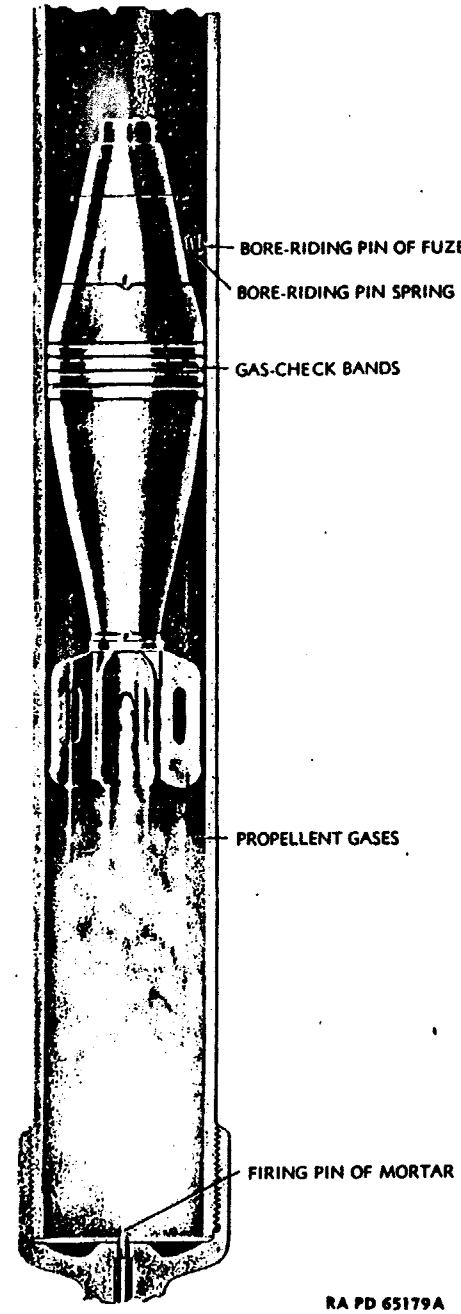

Figure 52 — 60-mm Mortar Shell Being Fired

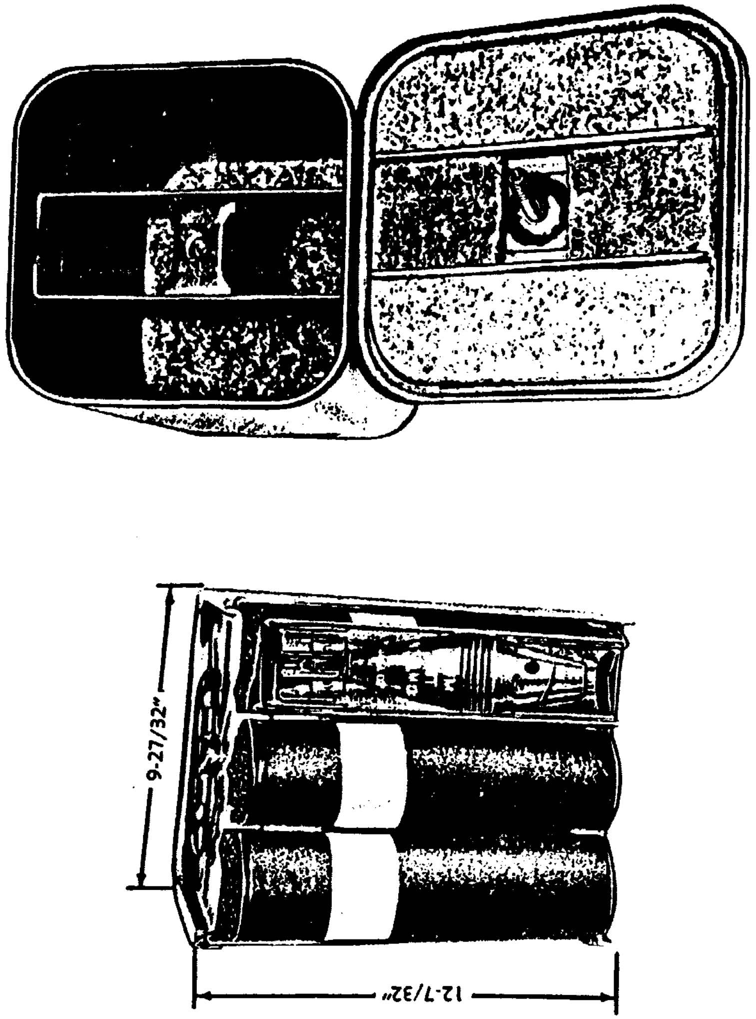

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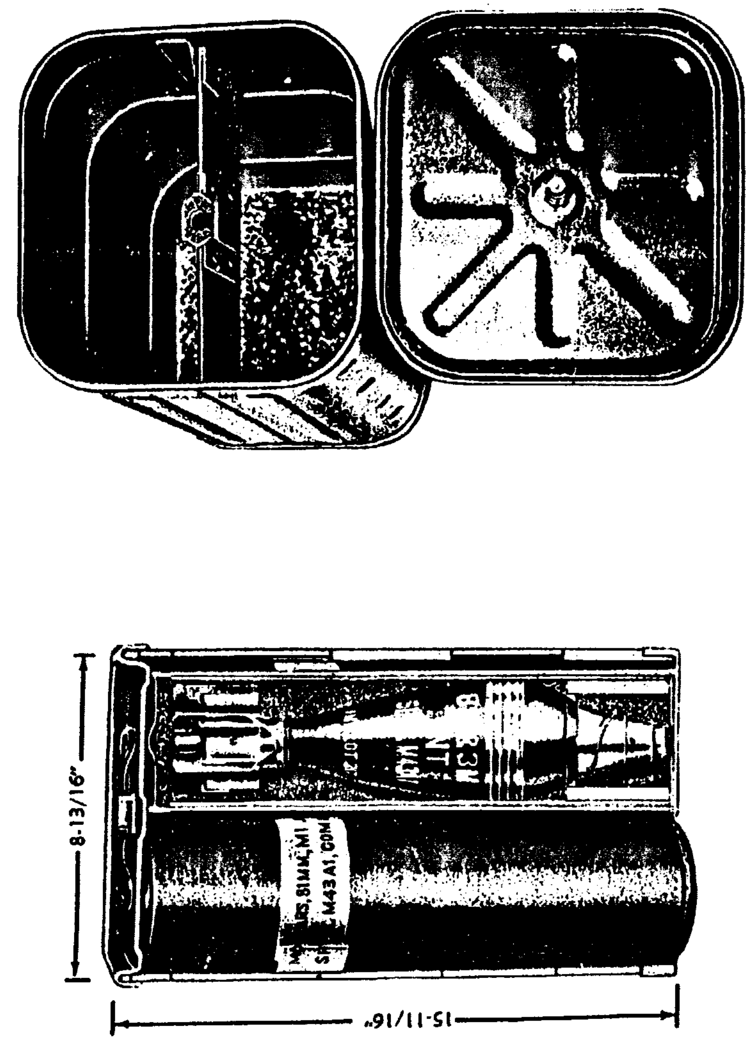
Figure 53 — Metal Container M139A1 for 60-mm Mortar Ammunition



RA PD 97686

Figure 54 — Metal Container M140A1 for 81-mm Mortar Ammunition

94. METHOD OF PROJECTION. The round is dropped into the mortar tube and upon reaching the bottom of the mortar, the round's primer impinges upon the firing pin of the mortar. This impact sets off the ignition cartridge and propelling charge, and the gas produced forces the round from the mortar (fig. 52). The bourrelet, or gas-check band, prevents practically all the gas from escaping past the shell, and provides a bearing surface for the round in its travel through the bore. A bore-riding pin in the fuze of the shell prevents the fuze from becoming armed until after it leaves the bore of the weapon.

95. PRECAUTIONS IN HANDLING.

a. Complete rounds, particularly rounds with fuzes, will be handled with care at all times. Explosive elements in fuzes and primers are particularly sensitive to shock and high temperature.

b. Do not break the moisture-resistant seal on the fiber container until ammunition is to be used.

c. The safety wire will be withdrawn from the fuze only just before firing and at no other time. Be certain the bore-riding pin is in place in the fuze at the time the shell is dropped in the mortar.

d. When loading muzzle-fed mortars, the round is inserted into the mortar, cartridge end first. When the shell is released to slide down the barrel, the hands should be promptly removed from the muzzle.

e. Duds should not be handled or moved. Because their fuzes are armed, they should be destroyed in place as described in chapter 4 of this manual.

96. PACKING AND MARKING.

a. **Packing.** Except training ammunition, which may be requisitioned by components, mortar ammunition in the smaller calibers is packed as assembled complete rounds. Each round is packed in an individual fiber container, and then in suitable outer packing. In the case of 60-mm and 81-mm mortar ammunition, clover-leaf bundles, wooden box, or metal containers have been in use. The metal container (figs. 53 and 54) is now the standard packing for this ammunition, but is reserved for shipment to certain theaters.

b. **Marking.** In addition to the painting which identifies the ammunition as to type, the following information is stenciled on the projectiles:

Caliber and type of mortar
in which fired
Kind of filler
Model of shell
Ammunition lot number

Section IV

ARTILLERY AMMUNITION

97. GENERAL.

a. **Complete round.** The term "artillery ammunition" refers to ammunition, except rockets, mortar ammunition, and shotgun shells, used in weapons having a bore diameter of more than 0.60 inch. A complete round of artillery ammunition comprises all of the components necessary to fire a weapon once and to cause the projectile to function at the desired time and place (blank and drill rounds excepted). These components are, in general, the projectile, the fuze, the propelling charge, and the primer. Dependent upon both the type of propelling charge and the method of loading into the weapon, complete rounds of artillery ammunition are known as fixed, semifixed, or separate-loading (fig. 55).

b. **Components of a complete round.**

(1) PROJECTILE. The projectile is ejected from a weapon by the gas pressure developed by the burning propelling charge. Other terms used in specific nomenclature of certain items in place of "projectile," are "shell" and "shot."

(2) FUZE. A fuze is a mechanical device assembled to a projectile to cause it to function at the time and under the circumstances desired.

(3) PROPELLING CHARGE. The propelling charge consists of a charge of smokeless powder in a cartridge case, cloth bag, or both.

(4) PRIMER. A primer is used to initiate the ignition of a propelling charge. It consists essentially of a small quantity of sensitive explosive and a charge of black powder.

c. **Fixed ammunition.** Complete rounds in which the propelling charge is fixed, that is, not adjustable, and which are loaded into a weapon in one operation, are known as "fixed" ammunition. As usually designed, the propelling charge is loose in a cartridge case which is crimped rigidly to the projectile. The primer is fitted into the base of the cartridge case. For certain calibers, rounds of fixed ammunition are termed *cartridges*.

d. **Semifixed ammunition.** This type of round is characterized by the loose fit of the cartridge case over the projectile so that the propelling charge may be accessible for adjustment for zone firing. Like fixed ammunition, it is loaded into the weapon in one operation. In the usual design of this type of ammunition, the propelling charge is divided into sections, each consisting of propellent powder in a bag. To adjust the propelling charge, the projectile is lifted from the cartridge case, the sections of increments not required are removed, and

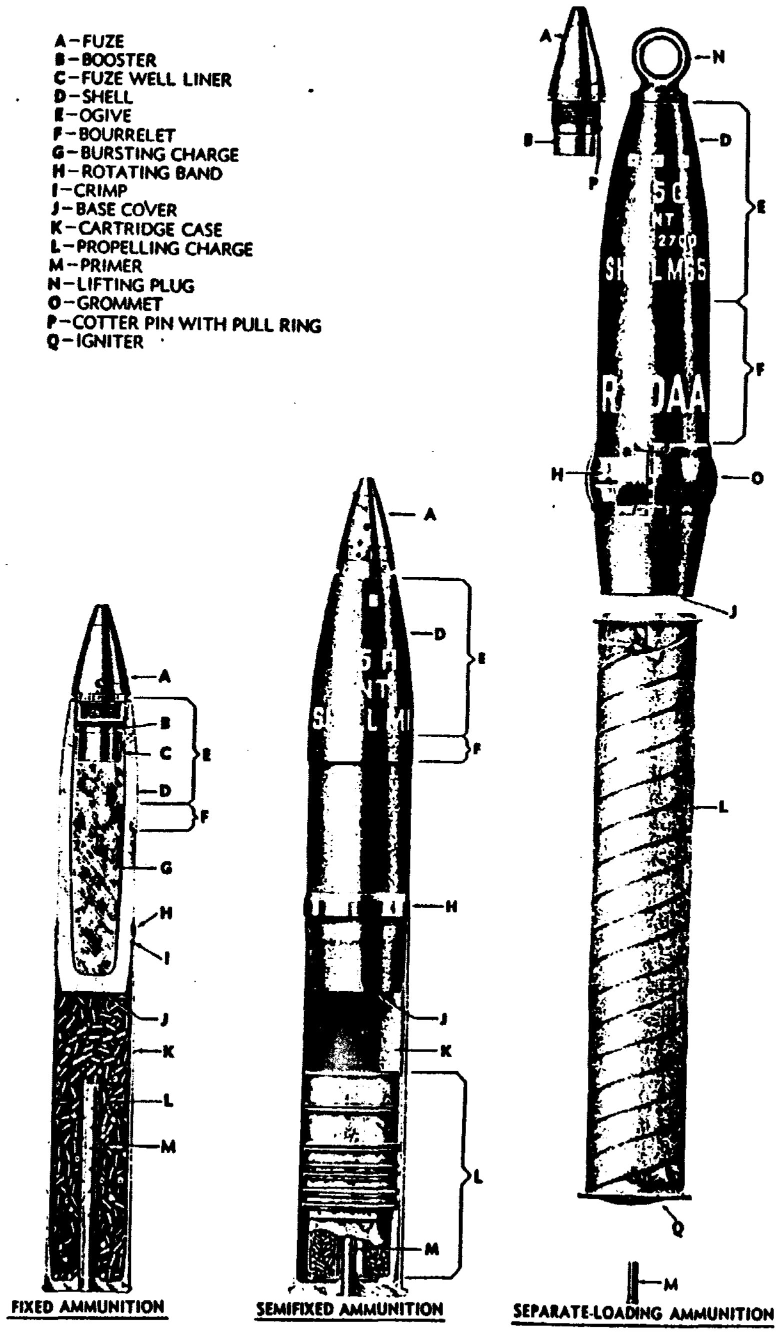


Figure 55 — Types of Complete Rounds of Artillery Ammunition

the projectile is reassembled to the cartridge case. As in fixed ammunition, the primer is assembled in the base of the cartridge case. The 105-mm howitzer HE,AT round is a special type in that the charge is fixed, that is, not adjustable; the cartridge case and projectile are not crimped together in this instance because of the method of packing.

e. **Separate-loading ammunition.** Complete rounds in which the separate components—fuzed projectile, propelling charge, and primer—are loaded into the weapon separately are known as "separate-loading" ammunition. Although the propelling charge may be in one section, it is usually divided into sections with each section assembled in a bag. In the case of "separated" ammunition (figs. 5 and 56), the propelling charge is contained in a cartridge case, but the projectile cannot be fitted into the cartridge case and is loaded into the weapon separately.

98. CLASSIFICATION.

a. Artillery ammunition is classified according to use as service, practice, blank, or drill. It is classified according to type of filler as explosive, chemical, or inert.

b. Service ammunition is fired for effect in combat. It may be high-explosive, high-explosive-antitank, armor-piercing or armor-piercing-capped (with or without explosive filler), low-explosive (shrapnel), chemical (gas or smoke), illuminating, or inert (canister).

c. Practice ammunition is provided for training in marksmanship. The projectile used may be inert or may have a spotting charge of black powder.

d. Blank ammunition is provided in small and medium calibers for saluting purposes and simulated fire. It has no projectile.

e. Drill or dummy ammunition is provided for practice in loading and handling ("service of the piece"). It is completely inert.

99. IDENTIFICATION.

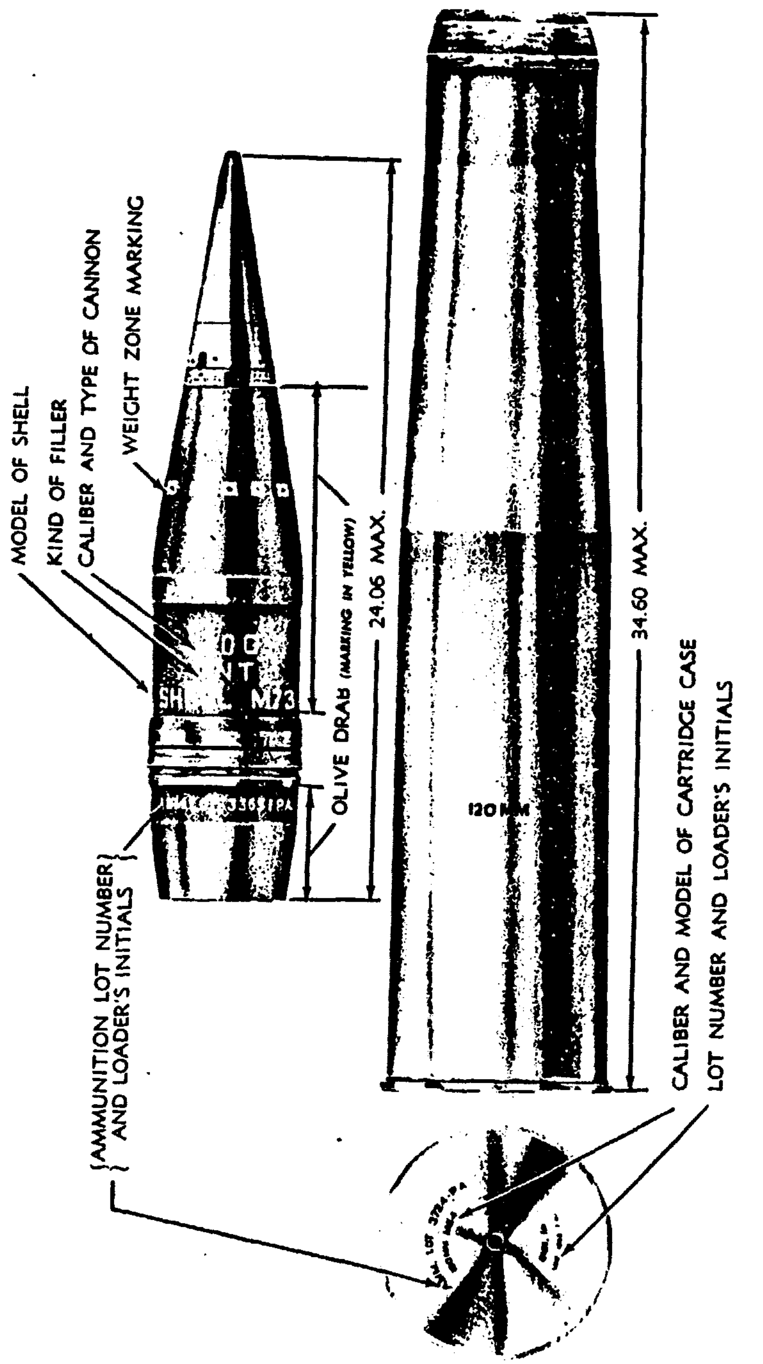
a. In common with other types, artillery ammunition is identified by painting and marking. For the basic color scheme, see chapter 1, section II. The marking on the projectile (figs. 2, 3, 57, and 58) includes:

(1) Ammunition Identification Code (AIC) symbol—on separate-loading shell.

(2) Caliber and type of weapon in which fired ("75 H," "155 G," etc.).

(3) Kind of filler ("TNT," "WP SMOKE," etc.).

(4) Type and model of projectile ("SHELL, M60," "PROJ. APC-T, M61A1," etc.).



RA PD 65171

Figure 56 — 120-mm Ammunition

(5) Weight-zone marking (crosses on 75-mm shell and squares on larger-caliber shell; squares on separate-loading shell have prick punches in their centers) or weight in pounds.

(6) Ammunition lot number of filled projectile and in some cases loader's initials.

b. Similar information is marked on other components. Further information is given in pertinent Technical Manuals and Field Manuals.

c. Markings are stenciled on cartridge cases of 75-mm, 76-mm, and 3-inch ammunition to indicate the type of propelling charge. These markings are illustrated in figure 4 for 75-mm gun rounds.

d. An exception to the basic color scheme is the case of 20-mm ammunition; the high-explosive-incendiary projectile has a red body and yellow ogive. Some target-practice projectiles of larger caliber are painted black; when replacement or repainting is required, they will be painted blue in accordance with basic color scheme.

100. PROJECTILES.

a. **General.** With a few exceptions, artillery projectiles are of the same general shape, that is, they have a cylindrical body, solid or hollow, and an ogival head. (Canister and base-ignition smoke shell have blunt heads.) The projectiles vary in length from 2 to 6 calibers. The principal characteristic differences are:

(1) Location of fuzes—point or base.

(2) Radius of ogive—smaller for low-velocity, larger for high-velocity projectiles.

(3) Rotating band—narrow for low-velocity, wide for high-velocity projectiles.

(4) Base—tapered ("boat-tailed") or cylindrical ("square") base.

(5) Armor-piercing cap—used only with armor-piercing projectiles.

(6) Windshield (ballistic cap or false ogive)—when required for improved ballistics.

(7) Filler—high explosive, gas, smoke, illuminant candle and parachute assembly, or others.

b. **Components.**

(1) OGIVE AND WINDSHIELD. The curved portion of the projectile from the bourrelet to the point is called the ogive. The radius of the ogive is sometimes expressed in calibers, the caliber being the diameter of the bore of the gun. The radius of the ogive influences the flight of the projectile and in present designs generally varies from 6 to 11 calibers. Since armor-piercing projectiles have a short

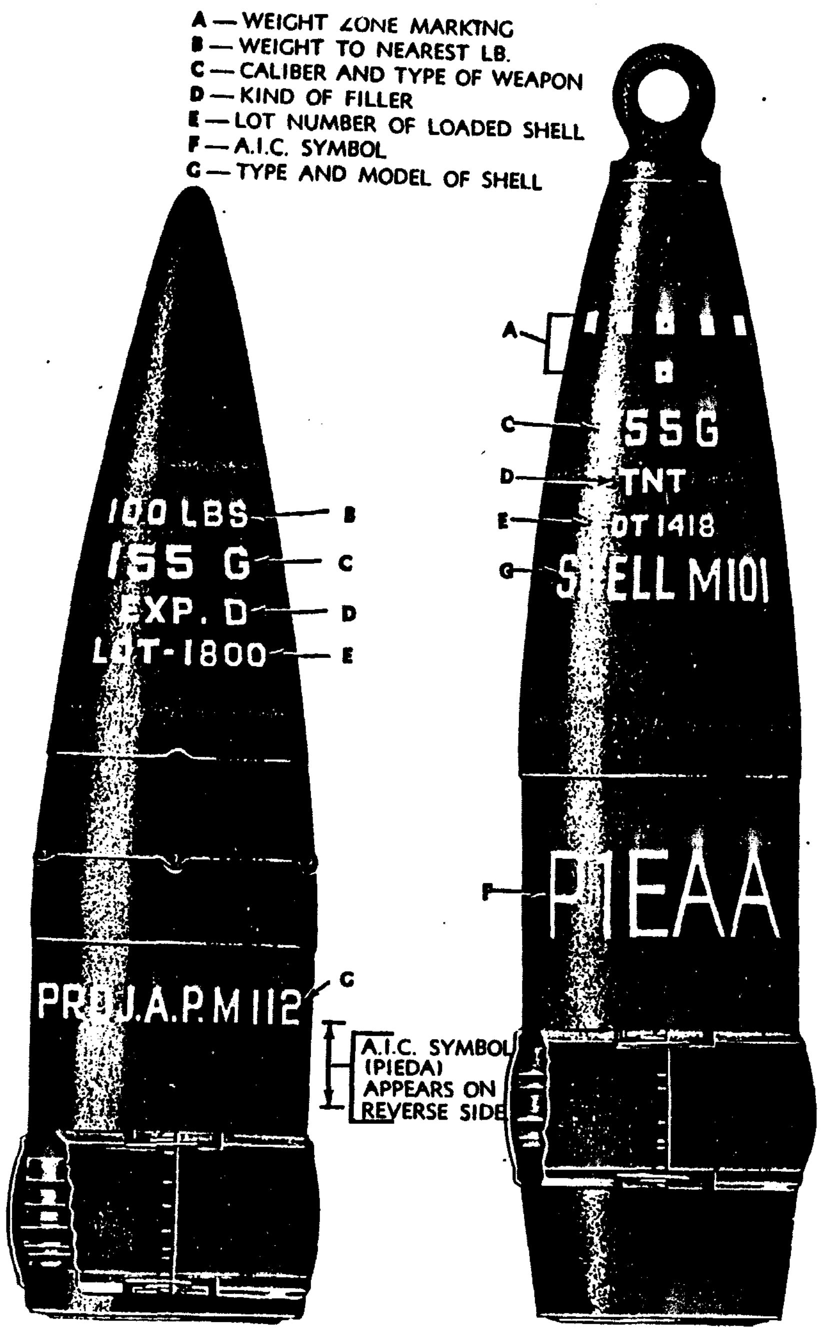


Figure 57 — Marking of Separate-loading Shell — As Shipped

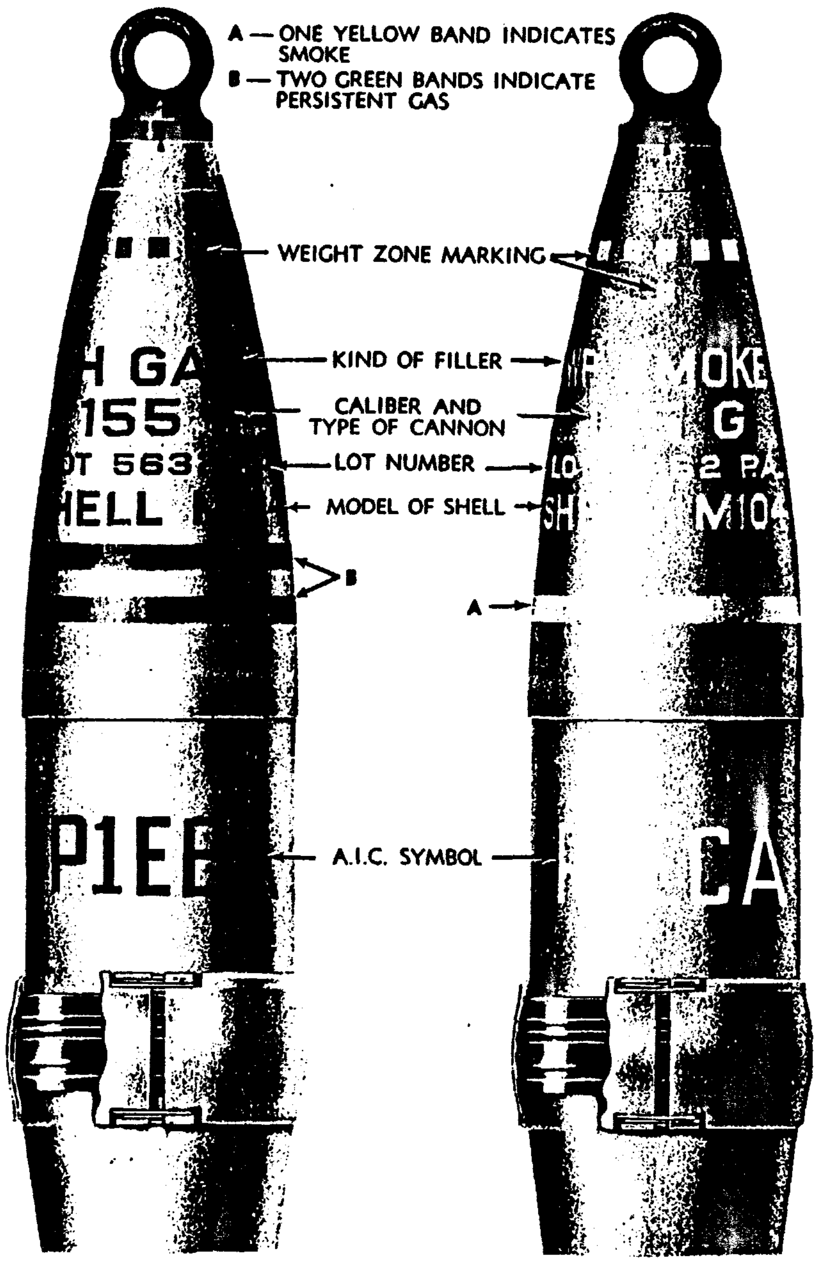


Figure 58 — Marking of Separate-loading Shell — As Shipped (Continued)

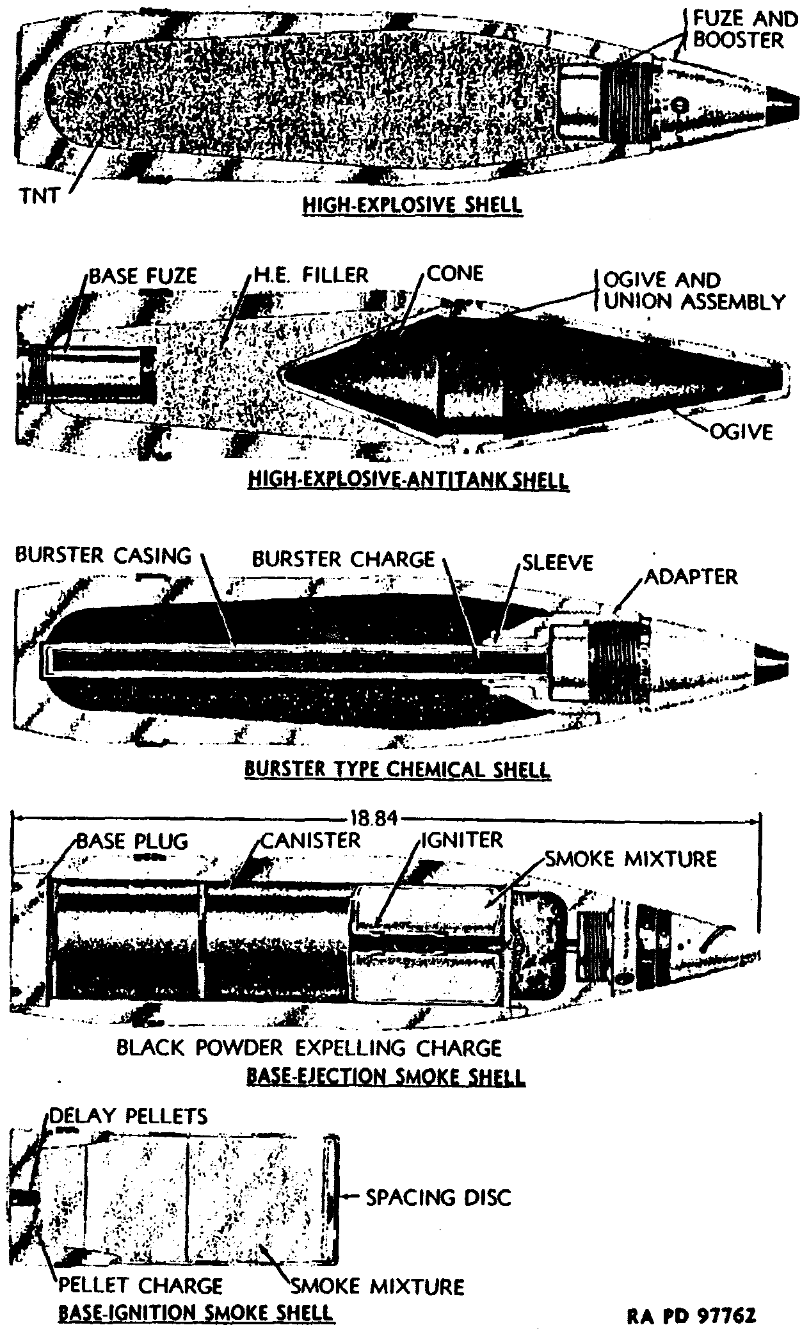


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Figure 59 – Typical High-explosive, High-explosive-antitank, and Chemical Projectiles

radius of ogive for purposes of penetration, a windshield, often called a ballistic cap or false ogive, is placed over the armor-piercing head to improve the ballistic qualities.

(2) Bourrelet. The bourrelet is the accurately machined surface, of slightly larger diameter than the body, which bears on the lands of the bore of the weapon. It centers the projectile in its travel through the bore. Generally, it is at the forward end of the body, but it may extend from the ogive to the boat-tailed base. Some projectiles of large caliber have a front and rear bourrelet.

(3) Body. While applicable to the entire projectile, the term "body" is used to designate the cylindrical portion of the projectile between the bourrelet and the rotating band. It is machined to a smaller diameter than the bourrelet to reduce the surface in contact with the lands of the bore. Only the bourrelet and rotating band bear on the lands.

(4) Rotating band. The rotating band is a cylindrical ring of copper or gilding metal, pressed into a knurled or roughened groove near the base of the projectile. It affords a snug seat for the projectile in the forcing cone of the weapon and centers the base in the bore. As the projectile moves forward, the soft rotating band is engraved by the lands of the bore. Because of compression of the band, excessive metal flows toward the rear. This flow of metal is taken up by grooves cut in the rotating band. Since the rifling of the weapon is helical, the engraving of the band imparts rotation to the moving projectile. The rotating band also prevents the escape of the propellent gases forward of the projectile by completely filling the grooves of the rifling.

(5) Type of base. When the surface to the rear of the rotating band is tapered or conical, it is known as "boat-tailed"; when cylindrical, the projectile is described as having a "square base."

(6) Base plug. To facilitate manufacture, armor-piercing projectiles are closed at the base with a heavy steel plug. In the larger calibers, the base plug adapter also provides a seat for the base plug and fuze. In the smaller calibers, if an explosive charge is loaded in the cavity of the projectile, the base plug is replaced by a base fuze. If no explosive is present in the smaller caliber projectile, the base plug contains the tracer element.

(7) Base cover. The 20-mm projectiles and projectiles of 75-mm or larger caliber containing high explosive, are provided with a base cover to prevent the hot gases of the propelling charge from coming into contact with the explosive filler of the projectile through joints or possible flaws in the metal of the base. The base cover consists of a thin metal disc which may be calked, crimped, or welded to the base of the shell. Small-caliber and medium-caliber armor-piercing projectiles with high-explosive filler and base fuzes are not ordinarily provided with base covers.

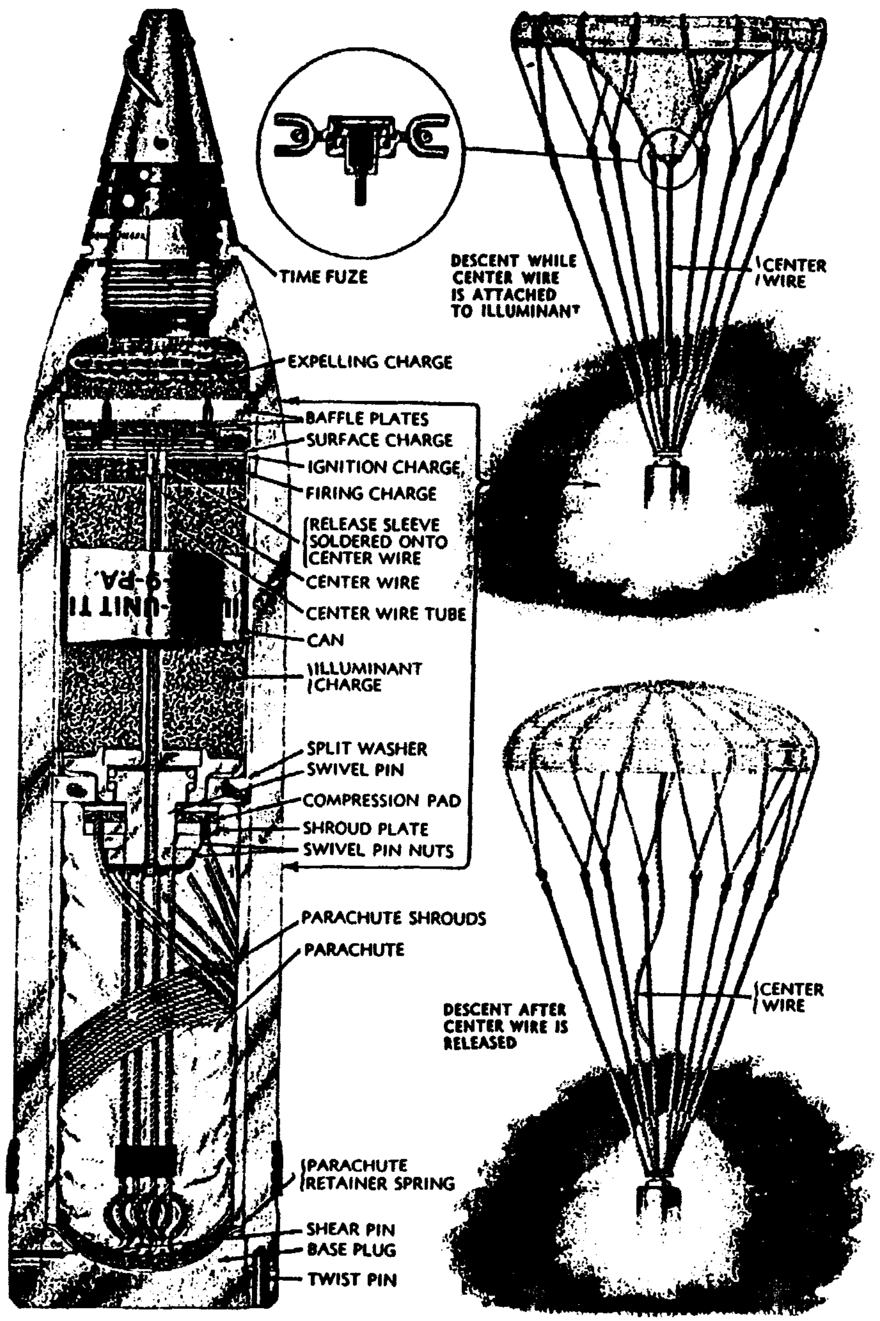
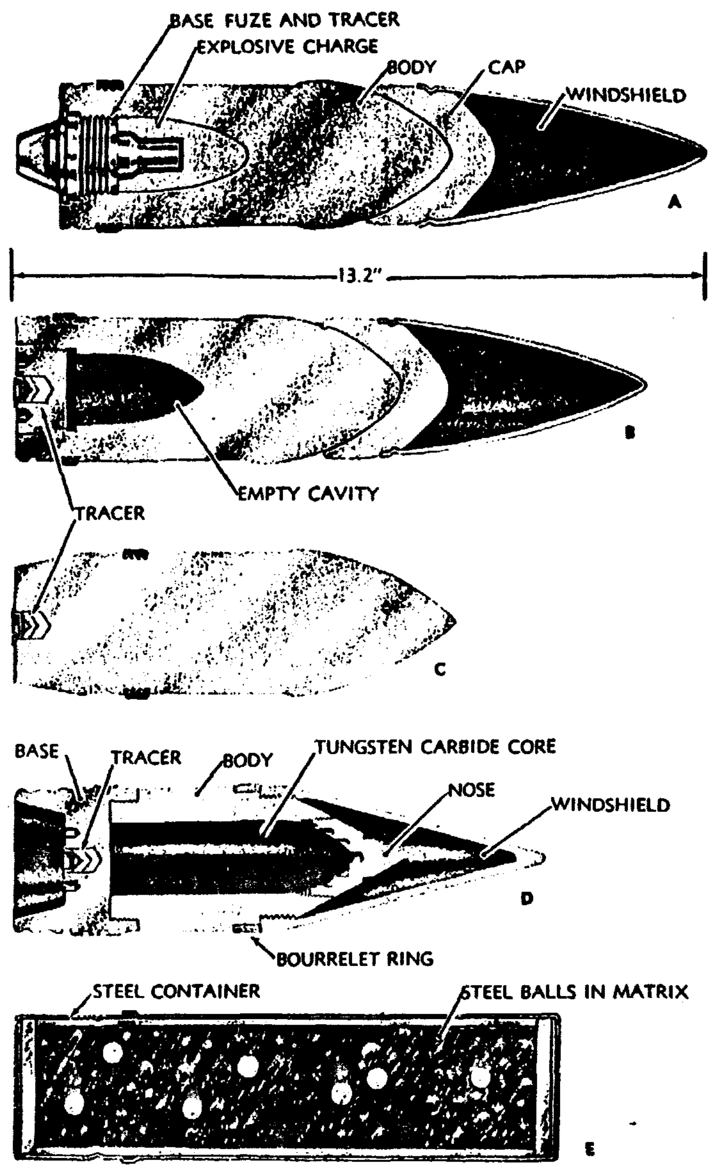


Figure 60 — Typical Illuminating Projectile



A — ARMOR-PIERCING-CAPPED PROJECTILE, WITH EXPLOSIVE FILLER
B — ARMOR-PIERCING-CAPPED PROJECTILE, EMPTY
C — ARMOR-PIERCING SHOT
D — HIGH-VELOCITY ARMOR-PIERCING SHOT
E — CANISTER

RA PD 97763

Figure 61 — Typical Armor-piercing and Canister Projectiles

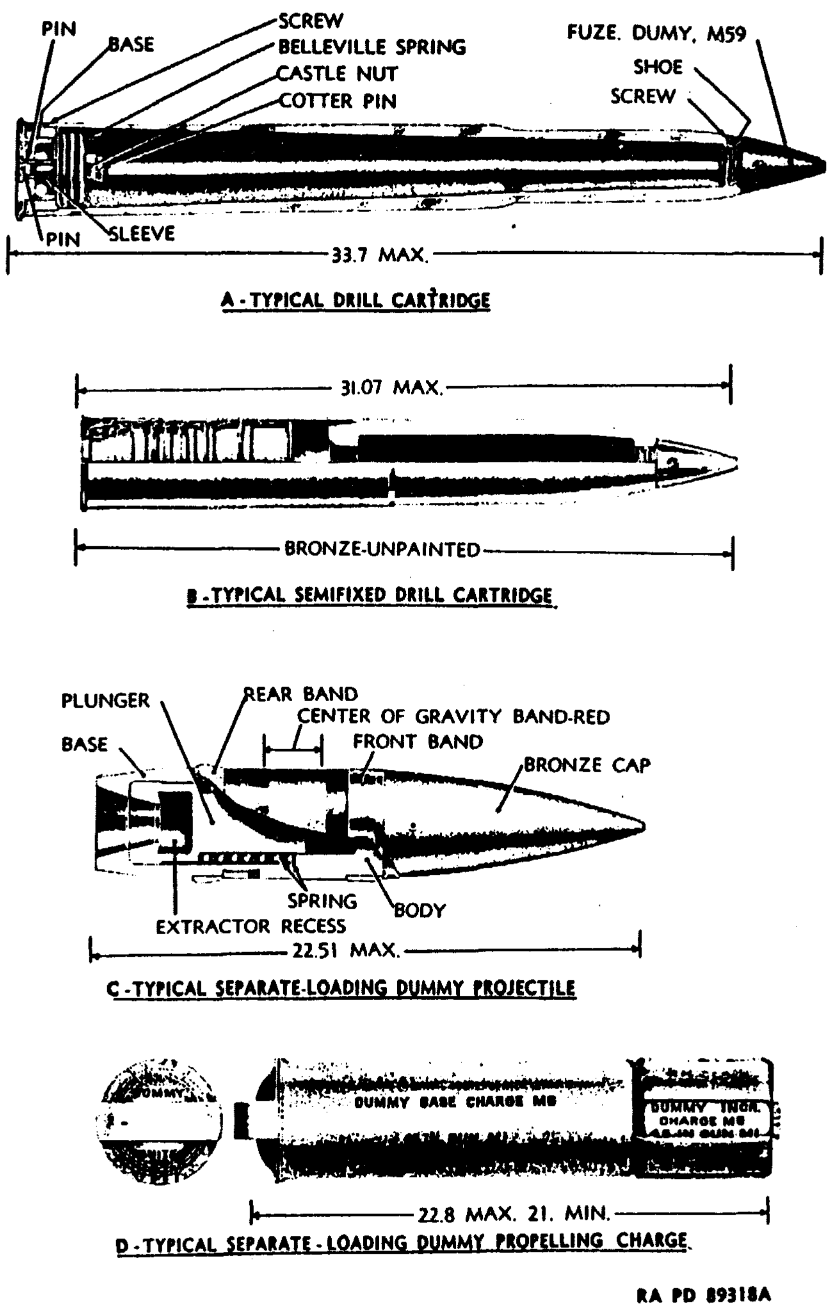


Figure 62 — Drill and Dummy Ammunition

(8) TRACER. For observation of fire, some projectiles are equipped with a tracer element in the base of the projectile. In most smaller-caliber antiaircraft shell, the tracer is used to ignite the filler and destroy the shell should it miss the target. Such a tracer is called "shell-destroying (SD)."

e. **Types of projectiles.**

(1) HIGH-EXPLOSIVE (HE) SHELL. This projectile (fig. 59), made of common forged steel, has comparatively thin walls and a large bursting charge of high explosive. It is used against personnel and material targets, producing blast and/or mining effect and fragmentation at the target. It may be fitted with either a time or impact fuze, on a concrete-piercing fuze, according to type of action desired.

(2) HIGH-EXPLOSIVE-ANTITANK (HE,AT) SHELL. This is a special type of shell (fig. 59) containing a high-explosive charge for use against armor plate. Its effect is dependent upon the type and shape of the charge. It has a conical windshield which provides stand-off for the charge, and a base-detonating fuze having nondelay action.

(3) CHEMICAL SHELL. There are three general types of chemical shell (fig. 59): burster, base-ejection (BE), and base-ignition (BI).

(a) Burster. The burster type is similar to high-explosive shell, except for the type of filler and the absence of a base cover. An explosive charge, termed a burster, and located centrally in the shell, is used to break the shell body and aid in dispersion of the chemical filler.

(b) Base-ejection (BE). Base-ejection shell which are set to function in flight do not have a burster, but have an expelling charge of black powder, adjacent to the time fuze. This expelling charge, when ignited by the fuze, ignites the smoke mixture of the canisters, strips the threads of the base plug, and forces the canisters from the base of the shell.

(c) Base-ignition (BI). Base-ignition (base-emission) smoke shell have no burster or expelling charge. The smoke mixture is ignited by the propelling charge through a hole in the base of the projectile. Shell of early manufacture have a low-melting-point fusible metal plug in the base hole, while shell of later manufacture have delay pellets of black powder. The action of the delay pellet prevents disclosure of the gun position by the smoke.

(4) ILLUMINATING SHELL. These shell (fig. 60) contain a parachute and an illuminant assembly which are ejected by an expelling charge adjacent to the time fuze in a manner similar to base-ejection smoke shell. The illuminant suspended by the parachute burns, lighting up a target area.

(5) ARMOR-PIERCING PROJECTILE (AP OR APC).

(a) Armor-piercing projectiles (fig. 61) are made of heat-treated high-carbon alloy steel. The head is very hard for penetration of armor and the body is tough to withstand the strains imposed by impact and the twisting action of the projectile at angles of impact oblique to normal. A windshield is generally secured to the armor-piercing cap or the head of the projectile to give improved ballistics. A tracer may be present in the base plug or in the base end of the fuze.

(b) Armor-piercing projectiles having no high-explosive filler may be solid or may have a small cavity in the body. When the cavity is filled with explosive D, the projectiles are fitted with a base-detonating fuze having a delay action.

(c) The term "armor-piercing-capped" (APC) refers to a shot or a projectile with an armor-piercing cap for use especially in penetrating face-hardened armor plate. The cap is of forged alloy steel, heat-treated to have a hard face and a relatively soft core. On impact, the hardened face of the cap destroys the hardened surface of the armor-plate, while the softer core of the cap protects the hardened point of the projectile by distributing the impact stresses over a large area of the head.

(6) HIGH-VELOCITY ARMOR-PIERCING SHOT (HVAP). This shot (fig. 61) is a high-velocity, light-weight projectile having a very hard armor-piercing core of tungsten carbide. The tungsten carbide core, a steel base containing a tracer element, an aluminum body and nose plug, and an aluminum windshield comprise the HVAP-T shot.

(7) CANISTER. Canister (fig. 61) consisting of a light metal case, filled with steel balls in a matrix, contains no explosives. It is fired point-blank for effect against personnel. The case breaks upon leaving the muzzle of the cannon, and the balls scatter in the manner of a shotgun shell.

(8) SHRAPNEL. Shrapnel are point-fuzed projectiles with a combination time and superquick fuze or a time fuze. An expelling charge of black powder is assembled in the base. A central flash tube connects the fuze and base charge. When the time fuze has burned its predetermined time, the magazine charge flashes through the central tube to ignite the base charge. This results in the ejection of the steel diaphragm, balls, head, and fuze from the case. The case is not ruptured. The balls are projected forward in the form of a cone, due to rotational velocity.

(9) TARGET PRACTICE.

(a) Cast-iron shot and sand-loaded shell of the same size, shape, and weight as the service shell it simulates are provided for target practice. Some models may have a small quantity of black powder

to serve as a spotting charge.

(b) Subcaliber ammunition consists of complete rounds of small caliber or small-arms cartridges used in practice firing of larger-caliber weapons. The subcaliber ammunition is fired from weapons fitted either on top of or in the bore of the larger weapon. The use of subcaliber guns and ammunition provides low-cost ammunition for training gun crews, avoids wear of the major weapon during practice, and permits firing where range limitations exist.

(10) DRILL OR DUMMY. Inert projectiles and complete rounds (fig. 62) for training are known as drill or dummy ammunition. They are used for training and practice in handling shell and in "service of the piece."

101. FUZES.

a. General. An artillery fuze (figs. 63 through 66) is a mechanical device used with a projectile to cause it to function at the time and under the circumstances desired.

b. Classification.

(1) Fuzes are classified according to position on the projectile as "point" or "base." They are further classified as "time" or "impact," or a combination of both. Time fuzes contain either a clockwork mechanism or a graduated time element in the form of a compressed black-powder train which may be set to a predetermined time prior to firing. Impact fuzes function on impact with the target. If the fuze is designed to function on impact with a very light materiel target, such as an airplane wing, it is called "supersensitive." Impact fuzes are further classified as superquick, nondelay, or delay. Delay on impact fuzes is usually 0.05, 0.15, or 0.025 seconds. These terms are used in reference to the action at the instant of impact, whereas "time" refers to length of time from the instant of the firing of the weapon to the instant of the functioning of the fuze.

(2) Selective-type fuzes have time action or more than one type of action, for example, superquick and delay, time and superquick (TSQ). Such fuzes can be adjusted in the field for the type of action desired. Time fuzes can be set to function at any desired time of flight after firing by turning a time ring.

c. Safety features.

(1) Artillery fuzes contain safety devices which tend to prevent functioning until after the fuze has been subjected to centrifugal and set-back forces, after the round to which it is assembled is fired.

(2) Certain fuzes are considered to be "boresafe." A boresafe (detonator-safe) fuze is one in which the explosive train is so interrupted that prior to firing and while the projectile is still in the bore of the gun, premature explosion of the shell is prevented should any of the more sensitive elements, primer and/or detonator,

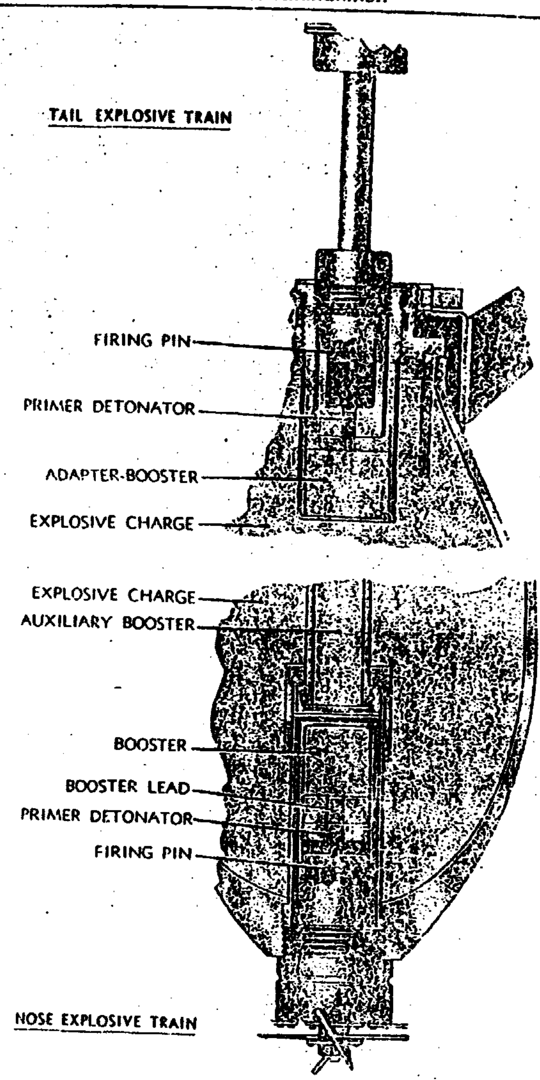


Figure 83 — Bomb Explosive Trains

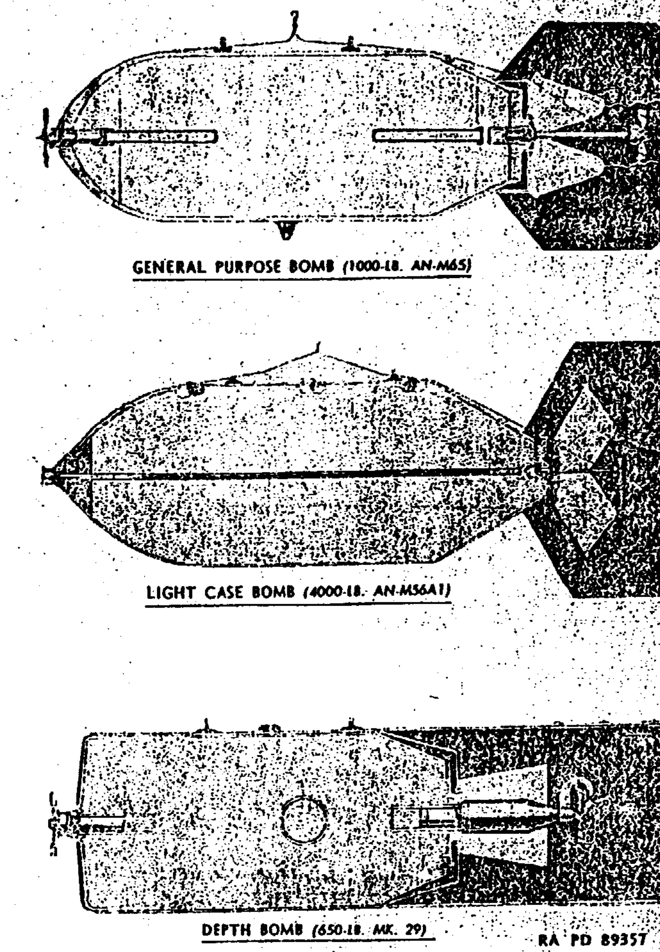


Figure 84 — Types of Bombs

c. **Light-case.** The light-case (LC) bomb (fig. 84) is similar in appearance to the general-purpose bomb but has a thinner, lighter case and contains a higher percentage of explosive filler by weight. Since strength of case has been sacrificed, this bomb cannot be used for penetration and must be fuzed to explode before the case breaks up on impact. Approximately 75 percent of the total weight is high-explosive filler.

d. **Armor-piercing.** The armor-piercing (AP) bomb (fig. 85) is used to pierce deck armor of battleships, heavy concrete structures, and similar highly resistant targets. The nose of the AP bomb is solid and sometimes is fitted with an armor-piercing cap (APC) (fig. 85). These bombs are effective against heavy deck armor when dropped from sufficient altitude to attain their rated velocity. They contain a relatively small percentage (8 to 18 percent) of explosive filler and use tail fuzes of the delay type.

e. **Semi-armor-piercing.** The semi-armor-piercing (SAP) bomb (fig. 85) is conventional in outline, resembling the cylindrical GP bomb. However, the SAP bomb has a heavy case of steel which is drawn into a thickened nose and contains approximately 30 percent by weight of explosive filler. It may be used against concrete pill boxes or other targets of moderately high resistance.

f. **Depth.** The depth bomb (fig. 84) is a special light-case bomb for use against submarines and surface craft. It averages 70 percent by weight of explosive. When detonated by a hydrostatic fuze, the effect of this bomb does not depend upon hitting the target directly but upon the shock of detonation of the explosive being transmitted through the water. The hydrostatic fuze functions at a predetermined depth rather than on impact. If it is desired to use these bombs for demolition effect only, they may be equipped with nose fuzes which function on impact. Fuzes may be of the nose or tail type or installed in a cavity running transversely through the bomb body.

g. **Fragmentation bombs.**

(1) Fragmentation bombs are for use against personnel and light materiel targets. The effect is produced primarily by the fragments of the bomb body projected at high velocity. The blast at the point of impact will cause additional damage to nearby objects. Some fragmentation bombs have stabilizing fins, others, for low-altitude bombing, have parachutes for retarding rate of fall (fig. 86). The design of the bomb body is such as to produce the greatest number of effective fragments. The body walls are of uniform thickness and may be made up of coiled helix springs. Any fragment having 60 foot-pounds of energy will disable personnel. Most types of fragmentation bombs are fitted with a nose fuze only. The weight of the high explosive in these bombs is about 15 percent by weight. Since the fragments are projected at approximately

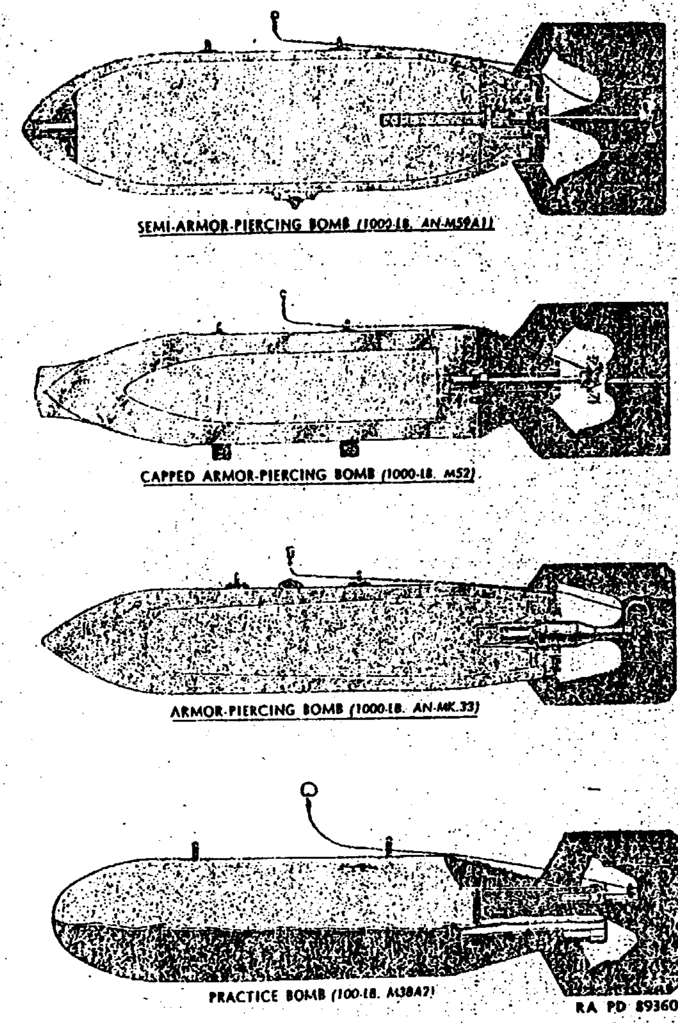


Figure 85 — Types of Bombs (Continued)

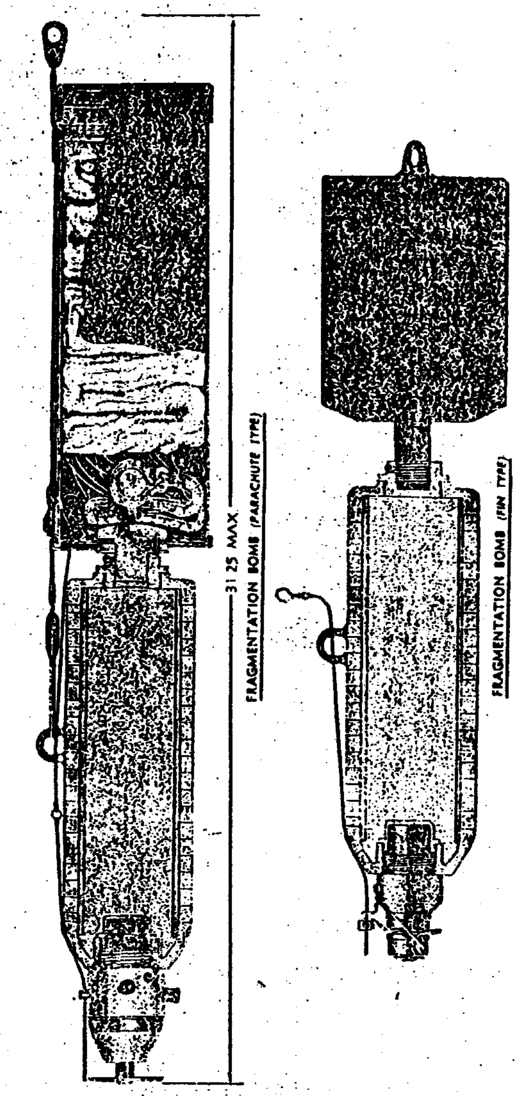


Figure 86 — Fragmentation Bombs

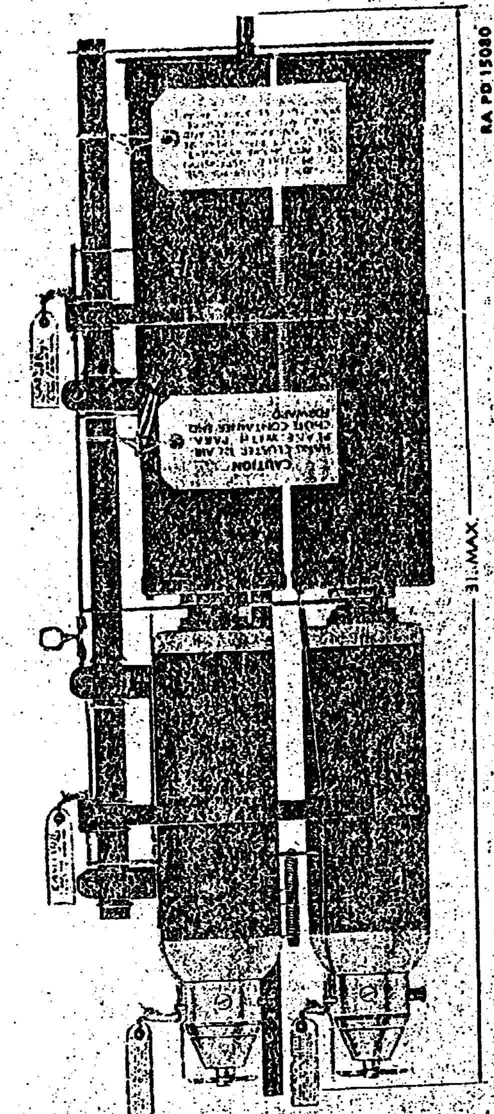


Figure 87 — Fragmentation Bomb Cluster

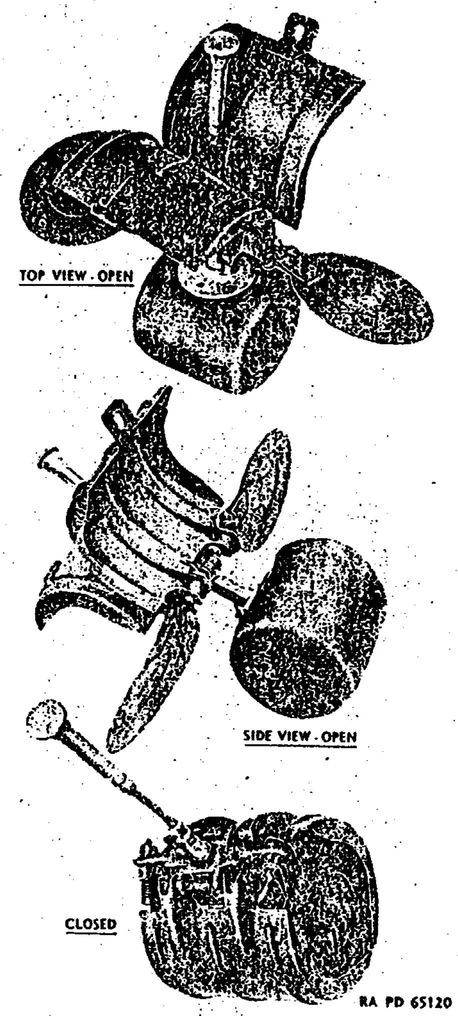


Figure 88 — 4-pound Fragmentation Bomb M83 (Butterfly Bomb)

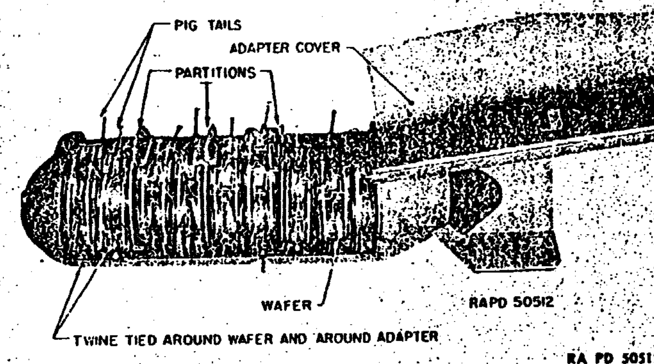


Figure 89 — Wafers in Place in Cluster Adapter

right angles to the axis of the bomb, the most uniform distribution and greatest destructive effects occur when the bomb is vertical at the instant of functioning.

(2) Fragmentation bombs stabilized by parachutes or fins are fitted with impact-type instantaneous-action fuzes. The bomb explodes instantaneously on impact, projecting a large number of fragments at high velocity.

(3) Small fragmentation bombs are assembled in clusters (fig. 87) for more efficient use and for ease in handling and dropping. Cluster adapters support the individual bombs and, in turn, are installed in stations for large-size bombs. The cluster is dropped from the airplane as a unit. The arming wire acts to release the bombs from the cluster, either by mechanical means directly, by arming a mechanical time fuze which opens a cluster after an interval, or by firing a cartridge which causes the cluster to open. Cluster adapters have been designed for almost every type of fragmentation bomb, including the butterfly bomb.

(4) The butterfly bomb (fig. 88) is equipped with a case assembly (butterfly wings) which is folded around it. When the cluster is opened, by action of a time fuze, the wings unfold by spring action and begin to rotate, retarding the fall of the bomb and arming its fuze mechanically. The cluster for the butterfly bomb in wafers is shown in figure 89.

(5) Aircraft mines and depth charges are similar to aircraft bombs and contain high-explosive fillers (figs. 90, 91, and 92).

113. CHEMICAL BOMBS. Chemical bombs (fig. 93) contain chemical agents which produce a toxic or an irritating physiological effect, or a screening smoke. They are known as gas or smoke,

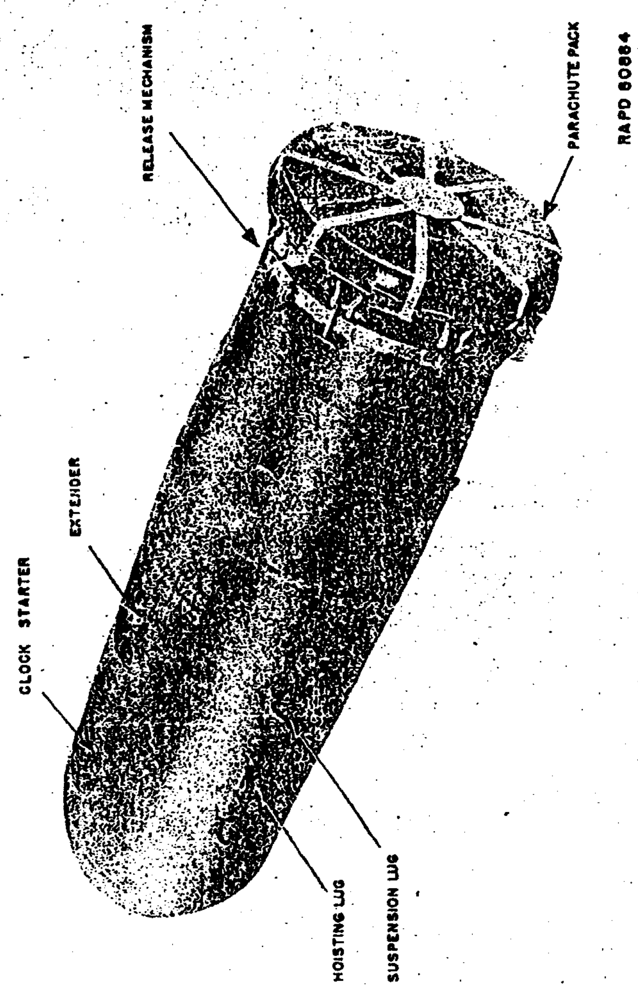


Figure 90 — Mk 26 Mod 1 Aircraft Mine

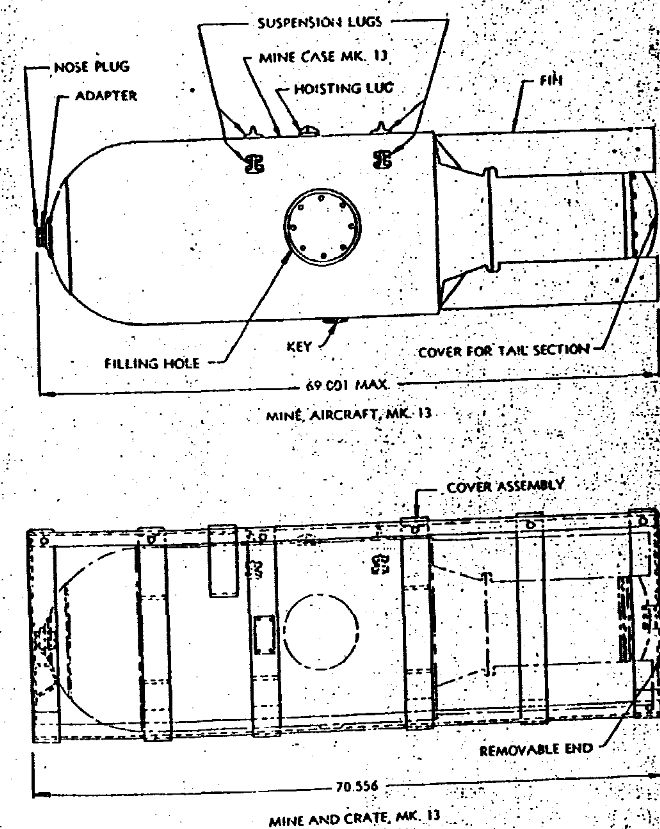


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Figure 91 — Mk 13 Aircraft Mine and Crate

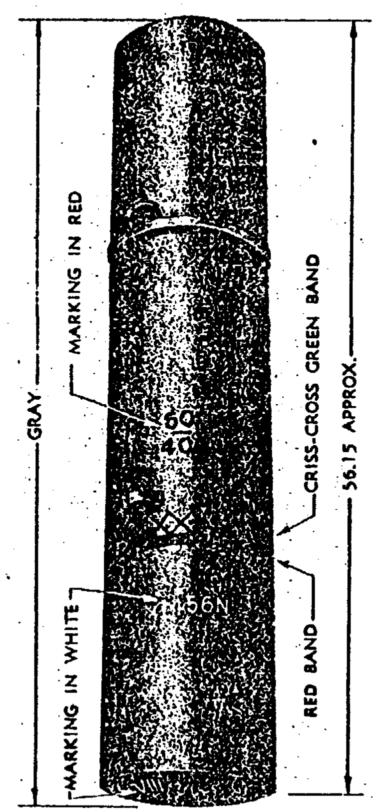

Figure 92 — Aircraft Depth Charge, 250-lb, Mk 8

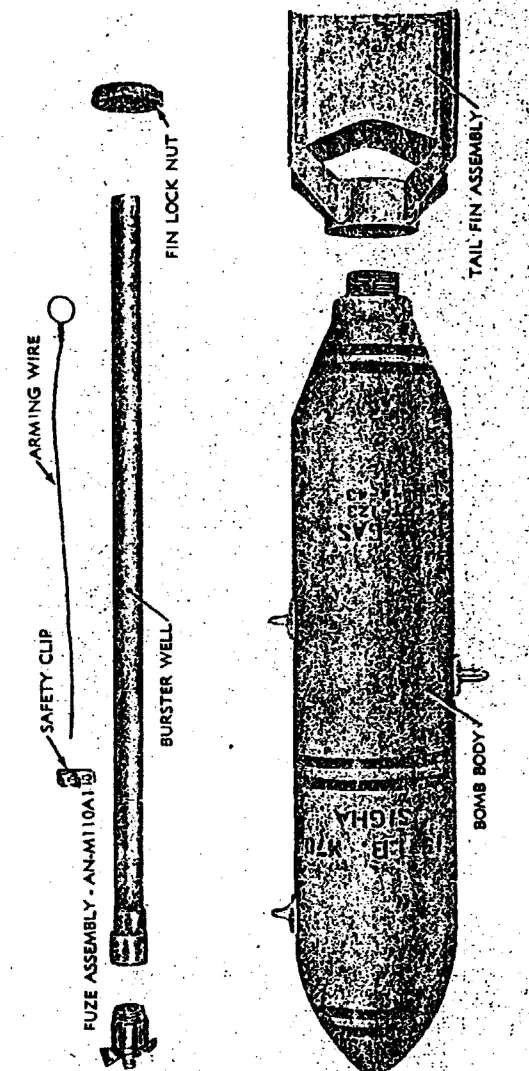

Figure 93—Chemical Bomb, H Gas, 115-lb, M70—Showing Components

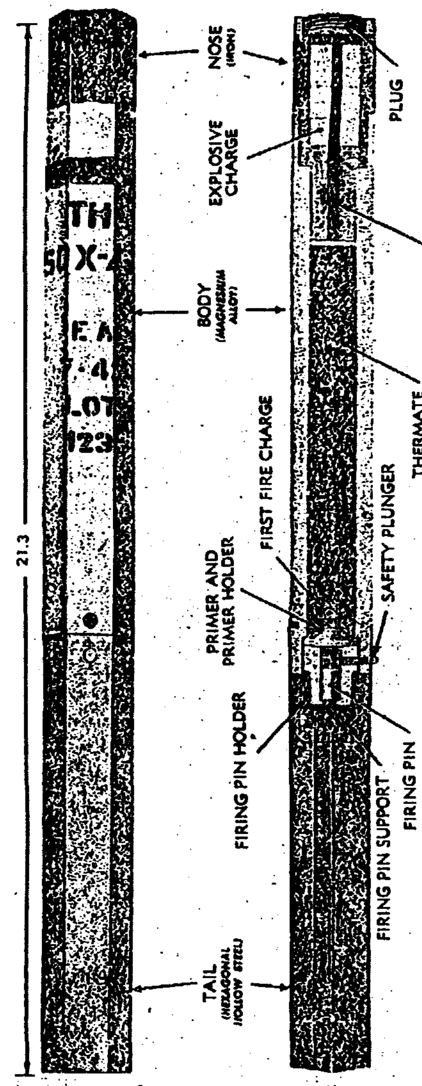

Figure 94 — 4-lb Incendiary Bomb AN-M50XA3

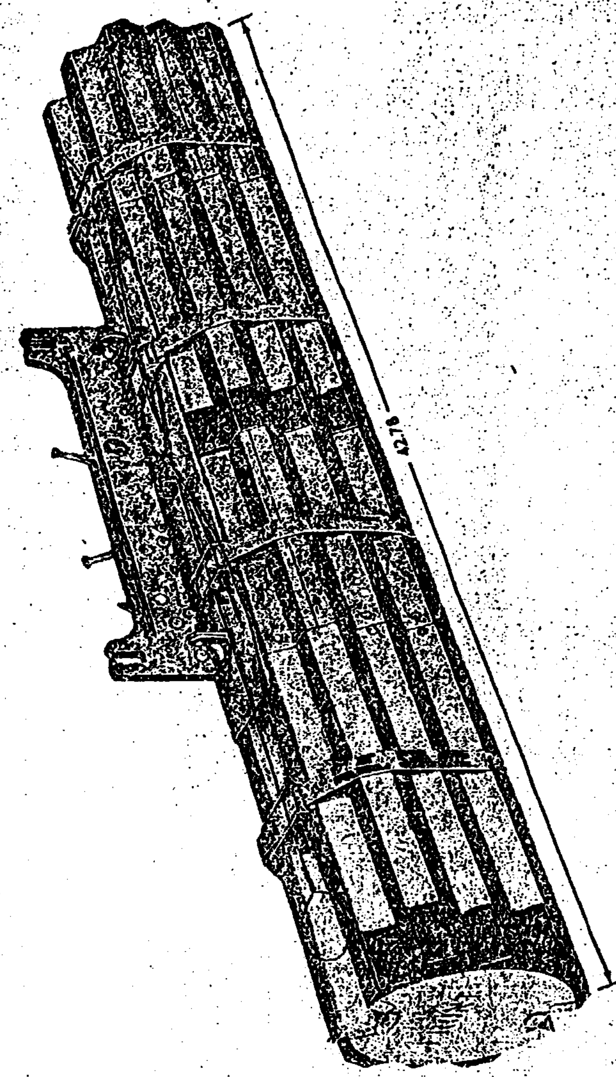

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Figure 95 — Incendiary Bomb Cluster

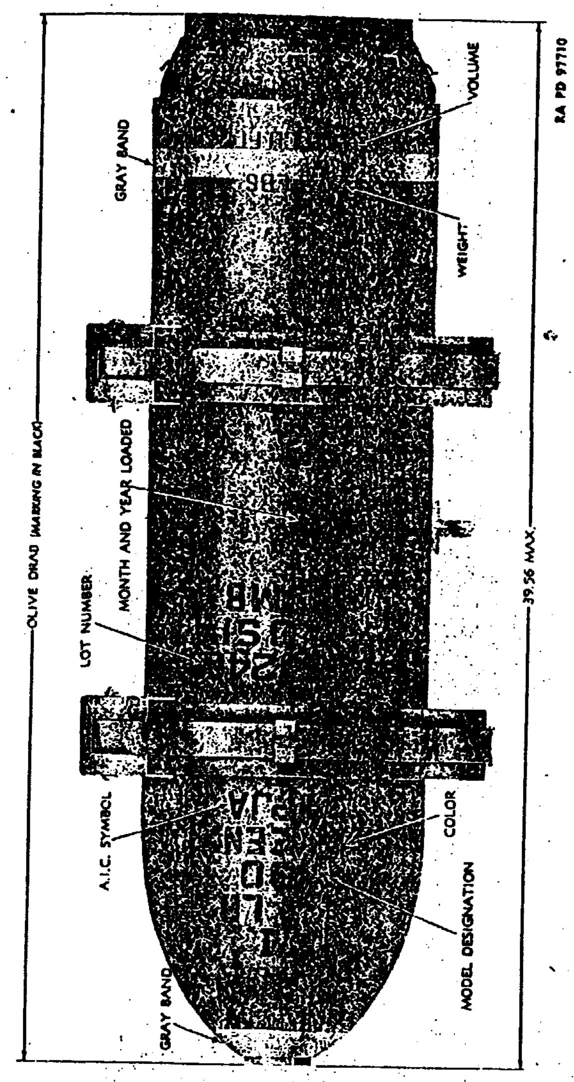

Figure 96 — 250-lb Green Target Identification Bomb M90 — As Shipped

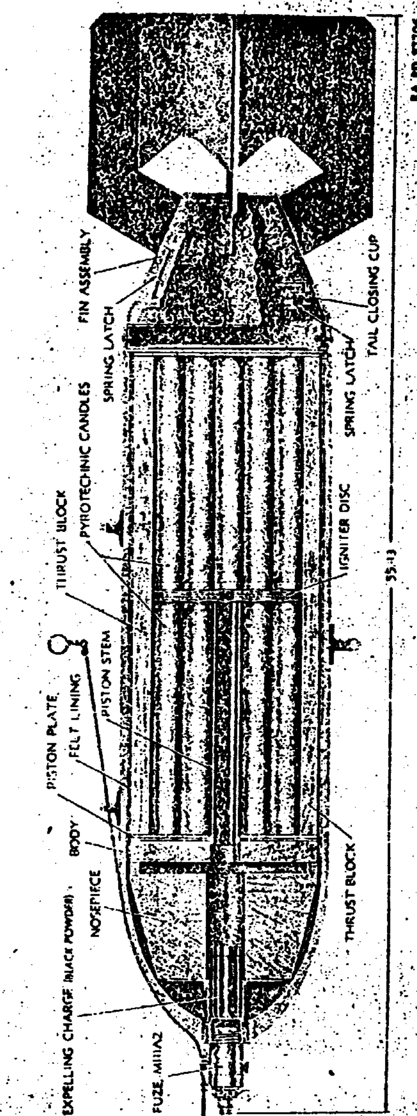

Figure 97 — 250-lb Green Target Identification Bomb M89, M90, or M98 — Typical Assembly

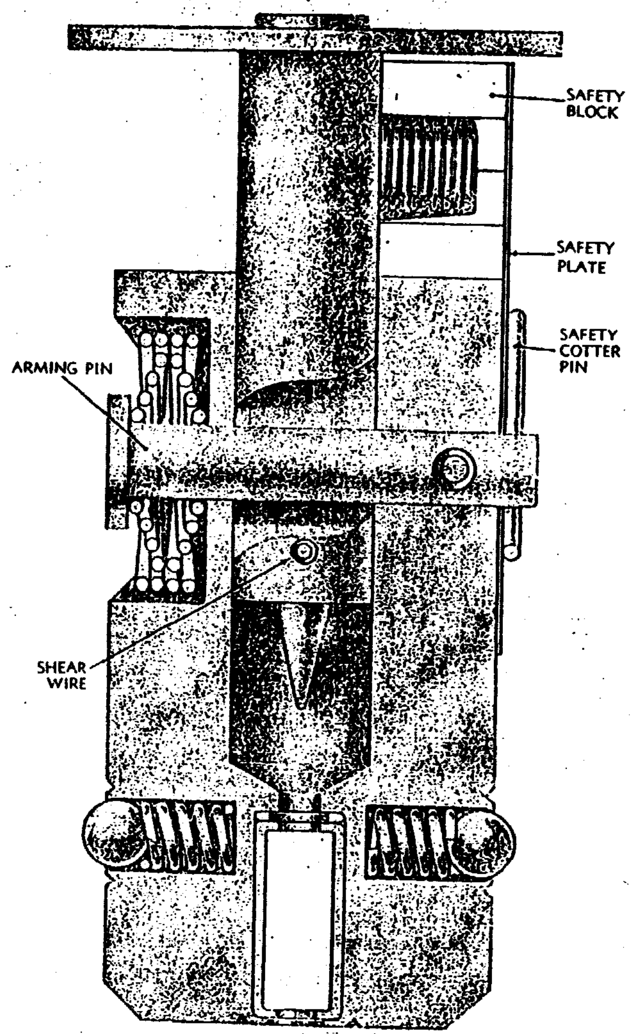

Figure 98 — Nose Fuze — Pin Arming Type (M108)

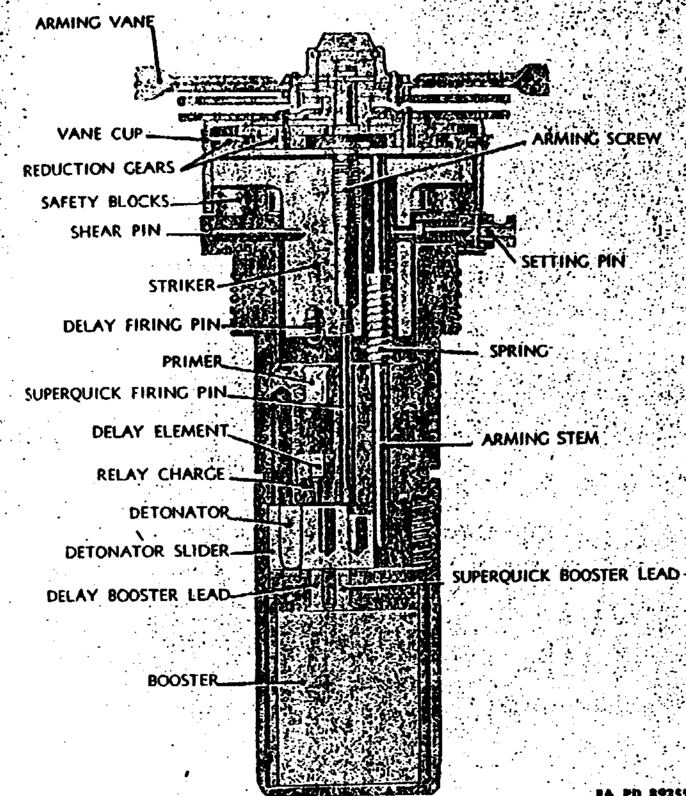

Figure 99 — Nose Fuze — Vane Arming Type

depending upon the principal effect. The force necessary to open the bomb body and properly disperse the chemical agent is provided by an explosive element called a burster, which extends the length of the bomb cavity. In general, the body serves only as a container for the chemical agent. Small chemical and incendiary bombs are hexagonal in shape to allow better packing in clusters (figs. 94 and 95). Fuze action is superquick (instantaneous) to prevent the waste of any of the charge by its being carried underground.

114. INCENDIARY BOMBS. Incendiary bombs contain jelled gasolene, oil, phosphorus, thermate, or magnesium fillers. Small

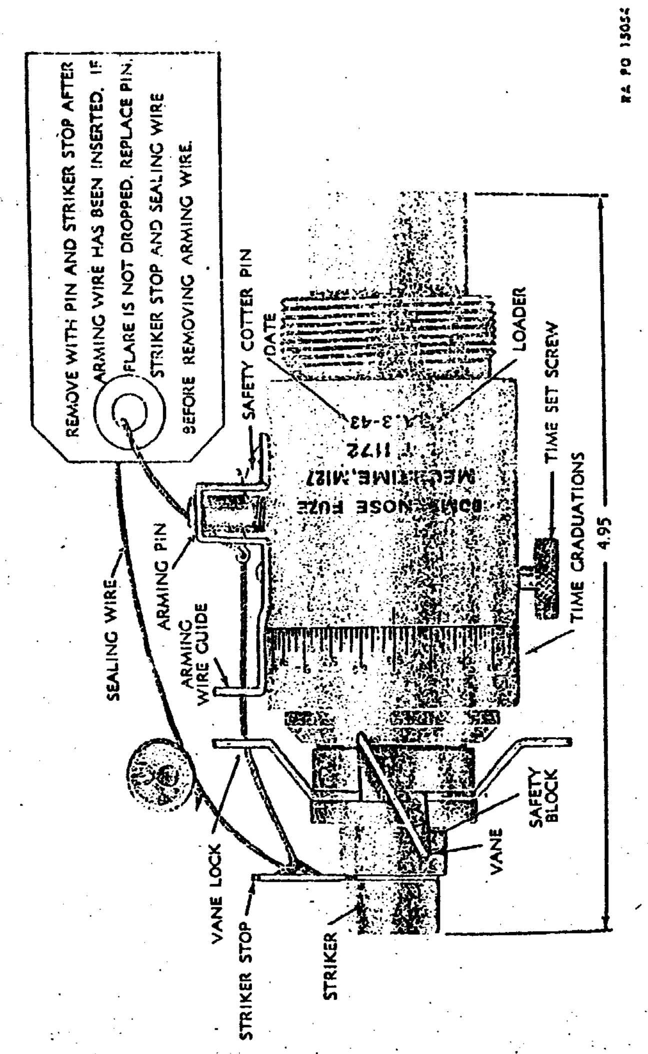

Figure 100 — Mechanical Time Bomb Fuze (Nose) M127

incendiary bombs (fig. 94) are hexagonal in shape and may have a steel case for an incendiary filler or a heavy magnesium alloy case containing an igniting charge; the case itself acts as the main charge. Small incendiary bombs are arranged in a cluster (fig. 95) which falls from the plane as a unit and then comes apart, allowing the bombs to arm and fall separately for coverage of an area target.

115. PYROTECHNIC AND TARGET-IDENTIFICATION BOMBS.

a. Photoflash bombs contain pyrotechnic material, but because of their explosive nature are called bombs (chap. 2, sec. VI.)

b. Certain skymarker, pathfinder, aircraft flares, and target-identification bombs produce a pyrotechnic effect but resemble bombs in appearance and use. The 100-pound red smoke target-identification bomb M84A1 falls from the aircraft for a length of time set on the bomb mechanical time fuze and then bursts in the air, producing a large cloud of red smoke. This cloud hangs in the air for a considerable period of time. The 250-pound target-identification bombs M89, M90, and M98 (figs. 96 and 97) illuminate and mark targets by the simultaneous ignition and tail ejection of their pyrotechnic candles at a height above ground determined by the selected setting on the mechanical time fuze. These candles fall to the ground and continue to burn for their prescribed time. Candles may be of the nondelay or exploding type.

116. PRACTICE BOMBS. Practice bombs (fig. 85) are provided for training in marksmanship. They may be sand-loaded at point of use and may contain a low-explosive spotting charge; for some uses, such as against water targets, the spotting charge may be omitted. These bombs simulate corresponding service bombs of the fragmentation and demolition types.

117. DRILL BOMBS. Completely inert bombs and components are provided for training of ground crews in assembling and handling operations. They are the same size and shape as standard bombs. Drill bombs are made up from the metal parts of service bombs, inert-loaded when necessary.

118. FUZES.

a. General.

(1) A fuze is a mechanical device designed to initiate a train of fire or a detonation under the circumstances desired. Fuzes are classified according to position as nose, tail, and transverse, and according to type of functioning as time, impact, and pressure. Time fuzes function a predetermined number of seconds after release. Impact

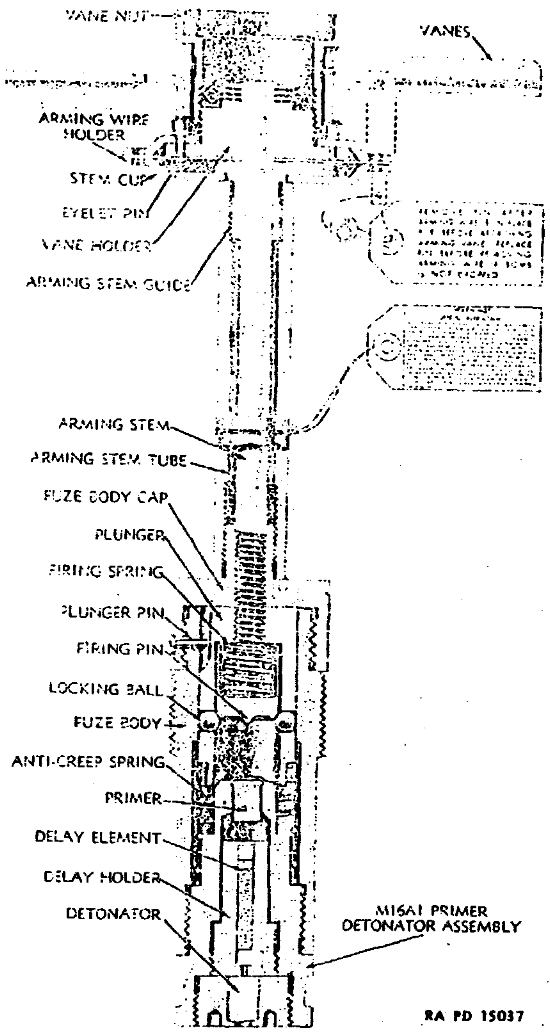

Figure 101 – Tail Fuze – Vane Arming Type (M112A1)

fuzes function when the bomb strikes a resistant material. Pressure fuzes function in response to water pressure (hydrostatic) or air pressure (concussion). Impact fuzes are classified as delay when they have a definite time lag between impact and explosion of the bomb, and as superquick (nose) or nondelay (tail) when there is no delay. Delay in fuzes varies from a fraction of a second to many hours and may be provided by a clockwork mechanism or a chemical reaction. Some delay fuzes are equipped with an antihandling device to function on an attempt to defuze the bomb.

(2) Bomb fuzes are shipped in a "safe" condition. They are constructed so that they cannot function when they are "safe" (unarmed). Most fuzes are designed so that an arming wire may be passed through parts of the fuze, mechanically restraining the firing pin or keeping elements of the fuze mechanism out of position until they are moved into functioning position, generally by the rotation of the arming vane. The arming vanes or similar arming mechanisms are held in place by a safety cotter pin which is replaced by the arming wire upon loading of the bomb into an aircraft. Dropping the bomb causes the arming wire to be withdrawn, which permits the fuze to arm. Arming-in-type fuzes may arm immediately on withdrawal of the arming wire or may have an arming delay element, timed by a clockwork mechanism or a powder train, which delays arming until a fixed time has elapsed. In arming-vane-type fuzes, the vane is rotated by the air stream as the bomb falls, a fixed number of turns being required to arm the fuze.

(3) Bomb fuzes are generally shipped separate from other bomb components. In most cases in the assembly of fuzes to bombs, tools are not used.

b. **Nose fuzes.** Nose fuzes, in general, are held unarmed by the presence of safety blocks between the striker and the fuze body, thus preventing the firing pin from being driven into the primer. Most nose fuzes have a primer, delay element, detonator, and booster assembled in the fuze body. The working parts of the fuze—except the arming mechanism and striker head—are protected by the bomb case, thus avoiding the possibility of the fuze being crushed on impact before it can function (figs. 98, 99, and 100).

c. **Tail fuzes.** Tail fuzes, in general, are held unarmed by an arming stem screwed into the inertia-type firing pin. In these fuzes, the booster is not assembled to the fuze but to the adapter-booster which is assembled to the bomb (fig. 101). For some fuzes, the primer-detonator assembled thereto may be changed in the field for other primer-detonators of other delay actions.

d. **Hydrostatic and concussion fuzes.** Hydrostatic fuzes (figs. 102 and 103) act under the influence of water pressure to explode the bomb a predetermined depth below the surface of the water.

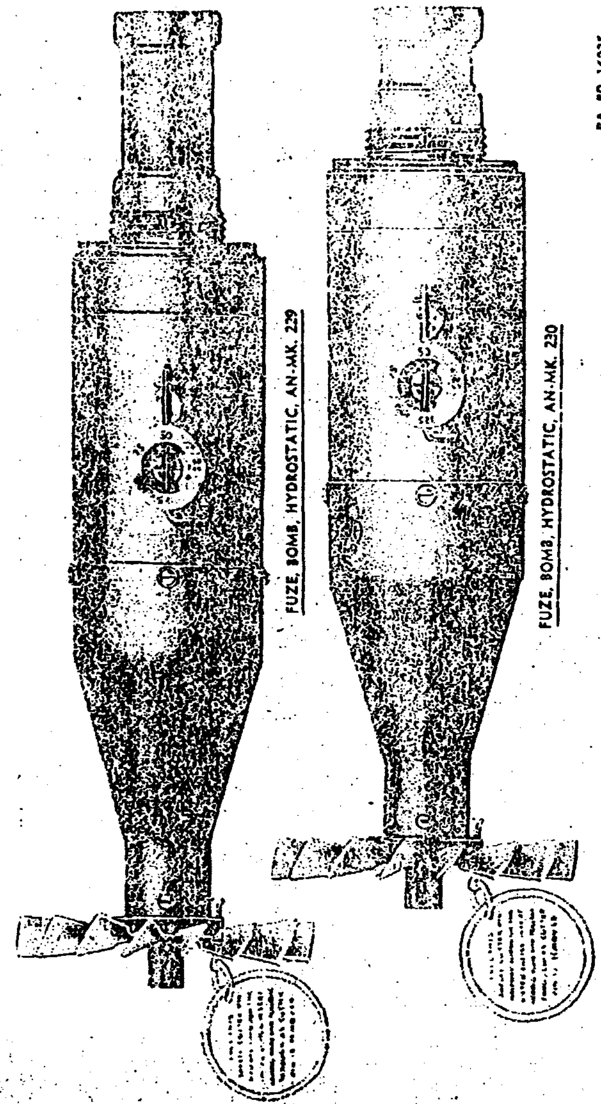

Figure 102 — Hydrostatic Bomb Fuzes AN-Mk 229 and AN-Mk 230

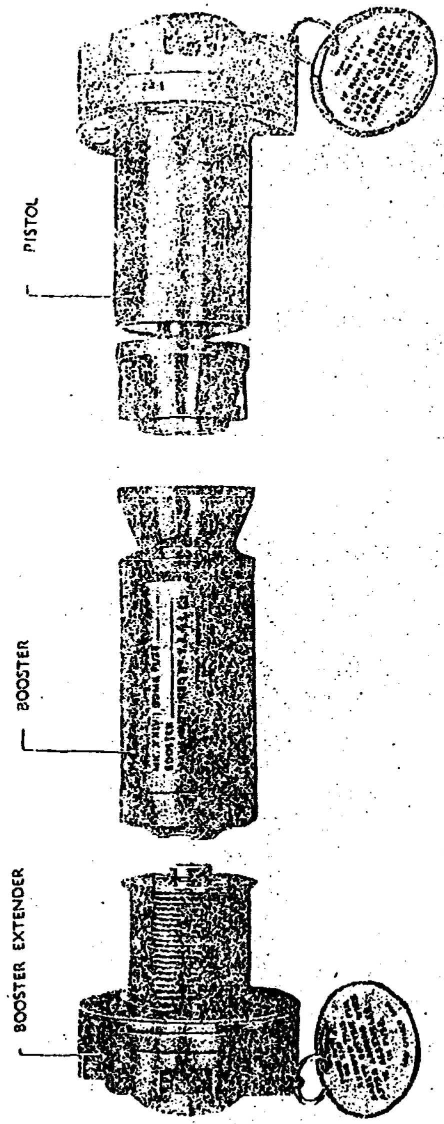

Figure 103 — Hydrostatic Transverse Bomb Fuze AN-Mk 24 Mod 1

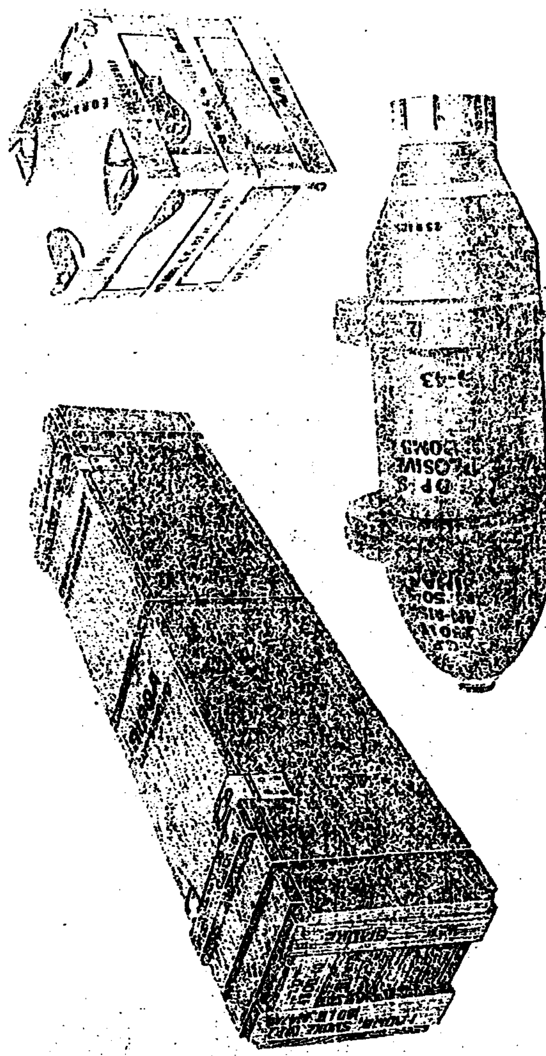

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Figure 104 — Packing of Bombs

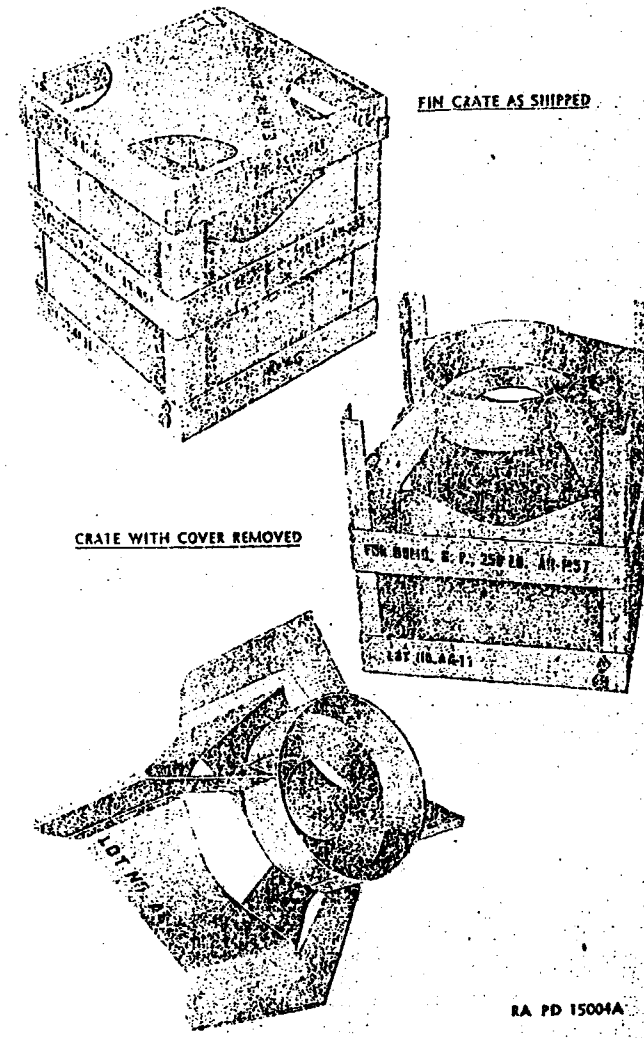

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Figure 105 — Packing of Bomb Fin Assembly

Concussion fuzes act in response to the concussion wave from the explosion of the preceding bomb in a salvo. Both of these fuzes function on the principle of a bellows or diaphragm working against a spring of fixed strength. When the external pressure overcomes the resistance of the spring, the firing pin is released and driven against the primer by spring action. In some fuzes, provision is made for adjustment by a mechanism controlling the compression of the diaphragm spring.

119. PACKING AND MARKING.

a. **Packing.** In general, bombs are shipped unfuzed with the fuze holes closed by metal shipping plugs. These plugs are not to be removed except for inspection and for assembly of the complete round. Large bombs are shipped with two paper or metal shipping bands which protect the suspension lugs. The fin assemblies of such bombs are shipped separately in metal crates. Smaller bombs are shipped finned, in metal crates. Small chemical and fragmentation bombs are packed in wooden boxes. Fuzes are packed in individual sealed containers and wooden boxes (figs. 104 and 105).

b. **Marking.**

(1) Wherever appropriate, the color scheme used for painting the bombs (chap. 1, sec. II) is used on the packing boxes or crates. All information for identification and directions for shipping are marked on containers for bombs and components, and on the bomb bodies when no container is used.

(2) A list of all separate components required for the complete round is sometimes stenciled on the shipping container in which these components are ordinarily packed. Usually, however, these components are stored separately and the word "WITHOUT" is stenciled above the list of components on the shipping container. If the separate components are packed with their respective bomb or fin assembly for shipment, the word "WITHOUT" is obliterated.

Section VI

PYROTECHNICS

120. GENERAL.

Military pyrotechnics (fig. 106) are fireworks which produce a brilliant light for illumination, or smokes and lights for signaling, in military operations.

121. CLASSIFICATION.

a. According to use, pyrotechnics are classified as:

(1) AIRCRAFT TYPES. Originally designed for use from or by aircraft.

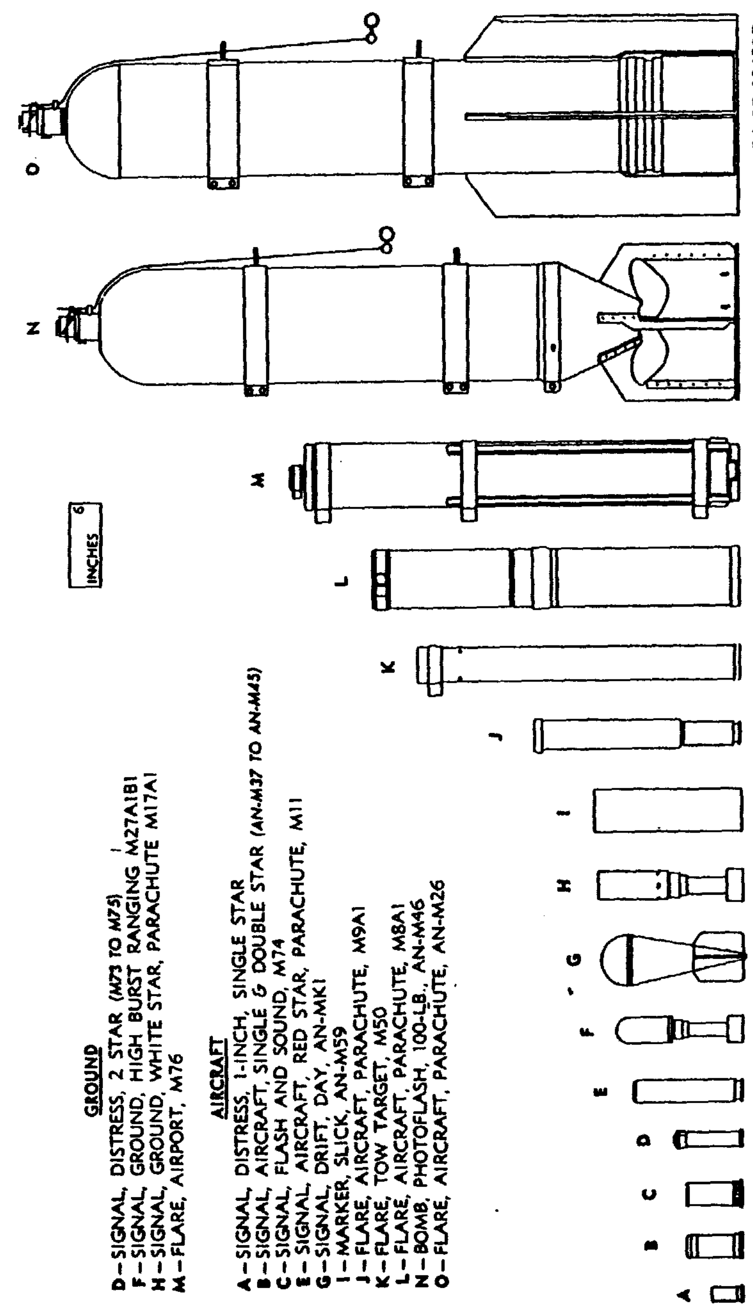


Figure 106 — Military Pyrotechnics: Types and Comparative Sizes

(2) GROUND TYPES. For use on the ground.

b. According to purpose they are classified as:

(1) ILLUMINANTS. Flares for illumination for a specific length of time, and photoflash bombs for an instantaneous flash for night photography.

(2) SIGNALS. Lights or smokes of various colors for transmission of messages.

c. Any of the above types when provided with a parachute is designated as a parachute type.

122. PYROTECHNIC COMPOSITIONS.

a. Pyrotechnic compositions are a mixture of chemicals which produce illumination.

b. Pyrotechnics generally function by means of an igniter train similar to the explosive train. In general, it is initiated by a primer mixture and intensified by a "first fire compound" which properly ignites the luminous candle.

c. Standard pyrotechnic compositions, in general, consist of compounds to provide oxygen for burning, such as perchlorates and nitrates; powdered aluminum or magnesium for fuel; salts of sodium, barium, copper, or strontium for color; and materials such as asphalt and paraffin for binding and waterproofing.

123. VISIBILITY OF PYROTECHNIC SIGNALS.

a. The principal factors controlling the effectiveness of pyrotechnics are design, position and atmospheric conditions.

(1) Factors of design include candlepower, color, and degree of separation of the parts of a composite signal.

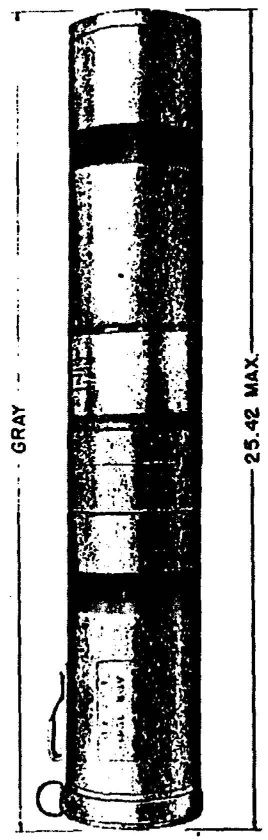
(2) Factors of position include height at which the flare or signal functions; distance of observer from signal; distance of flare from objective to be illuminated; background; and relative position of flare, objective, and observer.

(3) Atmospheric conditions include clarity of atmosphere; time (day or night); presence of haze, fog, dust, rain, or snow; and the color and brightness of the sky.

b. Tables of visibility, distinguishability, and distance are published in TM 9-1981.

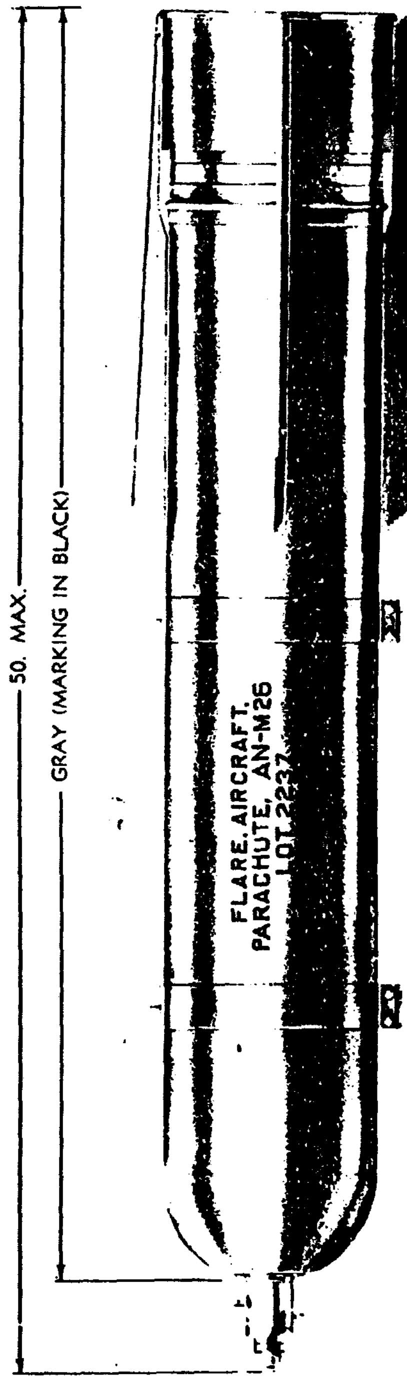
124. FLARES.

a. Flares are used to provide illumination for reconnaissance, observation, bombardment, landing, and practice firing of antiaircraft guns. While the details of flares vary with their purpose, all have certain common characteristics (figs. 107, 108, and 109):



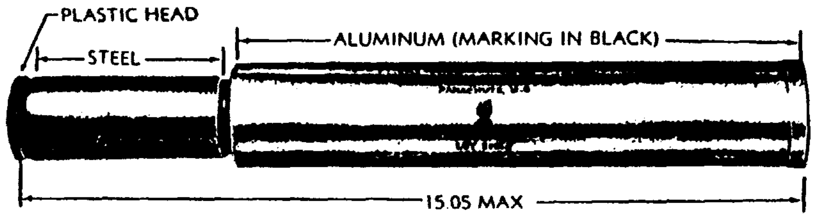
RA PD 4007

Figure 107 — Parachute Aircraft Flare M8A1



RA PD 4504A

Figure 108 — Parachute Aircraft Flare AN-M26



RA PD 64447

Figure 109 – Parachute Aircraft Flare M9A1

(1) Production of a white or yellowish light of high intensity ranging from 60,000 candlepower for 1 minute to 1,000,000 candlepower for 3 minutes or longer.

(2) Parachute support, to retard their speed of fall, thus providing efficient illumination for observation.

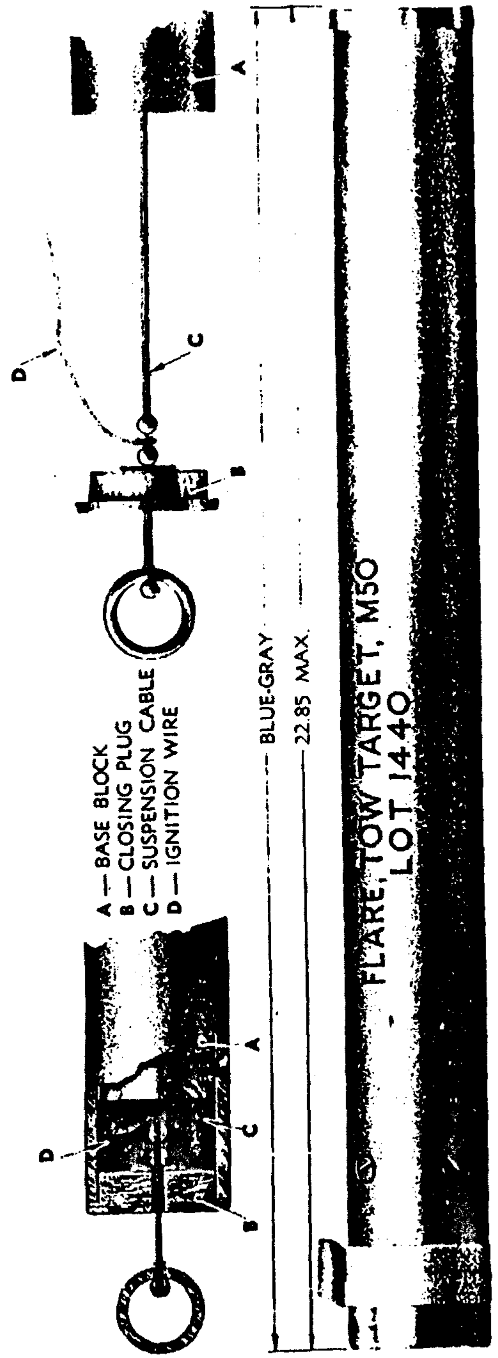
(3) Delayed ignition, to assure their reaching a specified altitude before ignition. Ignition is usually controlled by the opening of the parachute by means of a wire attached to the parachute cable or shock absorber, this wire pulling ignition wires through the igniting composition. The flame thus produced is then carried by quickmatch to the primer, first-fire charge, and the illuminant composition of the candles.

b. Flares for use below a plane, such as those intended for bombardment purposes, are provided with shades to shield the bombardiers from the glare.

c. Flares that are to be released from launching tubes or racks are equipped with a hangwire assembly which is attached to the arming pawl of the tube or rack. The flares may be released "armed" or "safe." When the flare is released "armed," the hangwire remains attached to the plane and pulls out the parachute or stabilizing sleeve. A section of soft metal tear wire enables the flare to break free. If released "safe," it will not function in the air but may ignite on impact. This possibility must be kept in mind in releasing flares safe over friendly territory.

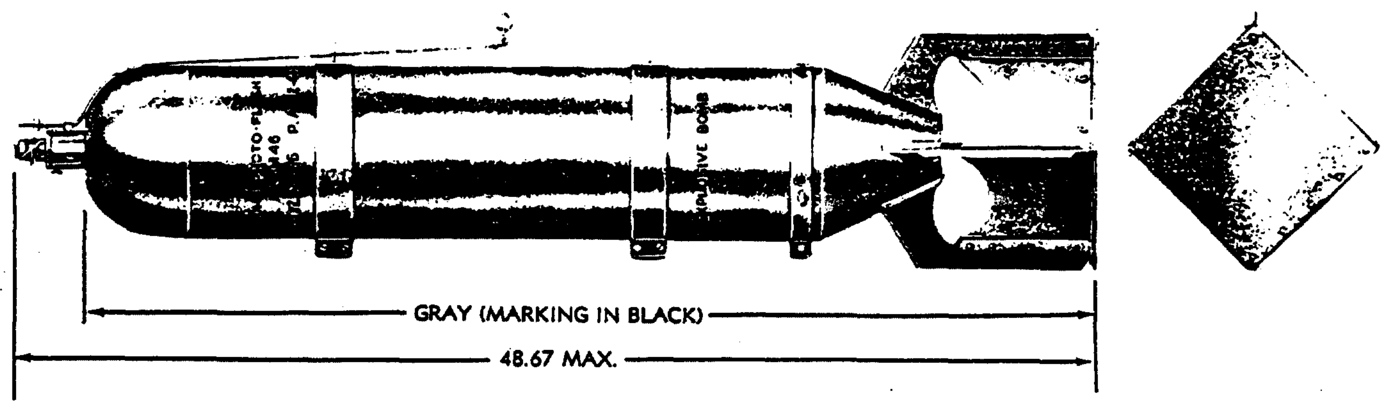
d. The flare provided as a target for both day and night practice firing of antiaircraft guns, is towed by a plane at the end of a steel cable. See figure 110.

125. PHOTOFLASH BOMBS. This ammunition item (fig. 111), called "bomb" because of its explosive nature, provides a brilliant light of short duration for night photography. A photoflash bomb which is dropped safe, or whose fuze fails to function, may detonate on impact. The flash from photoflash bombs, even at distances prescribed as safe from bomb fragments, is injurious to the eye because



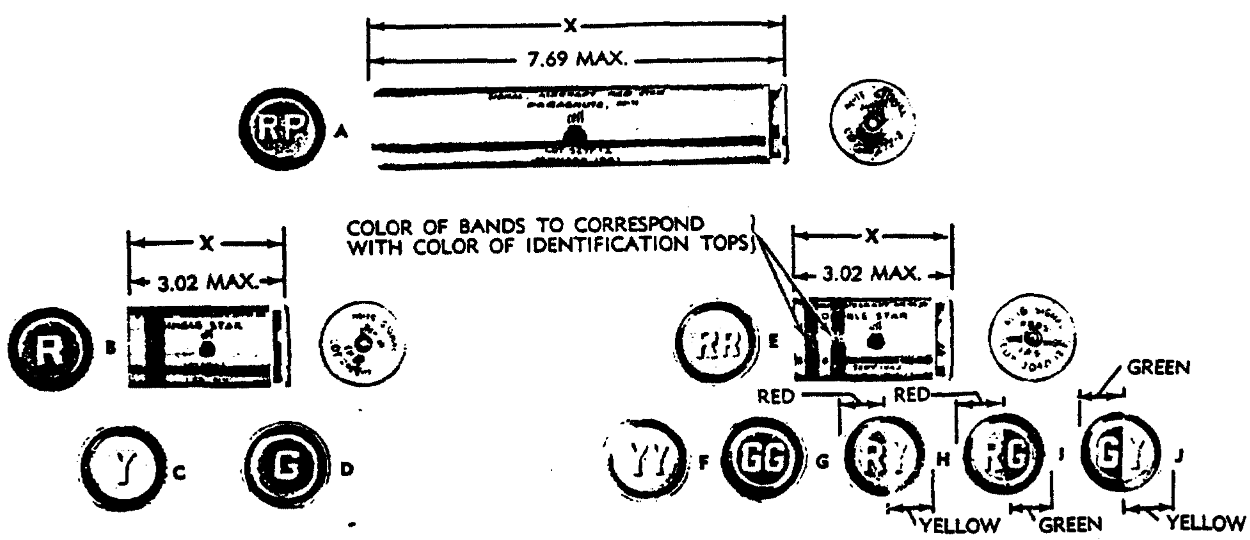
RA PD 69070A

Figure 110 — Tow-target Flare M50



RA PD 72418

Figure 111 — Photoflash Bomb M46



IDENTIFICATION TOP FOR: / COLOR

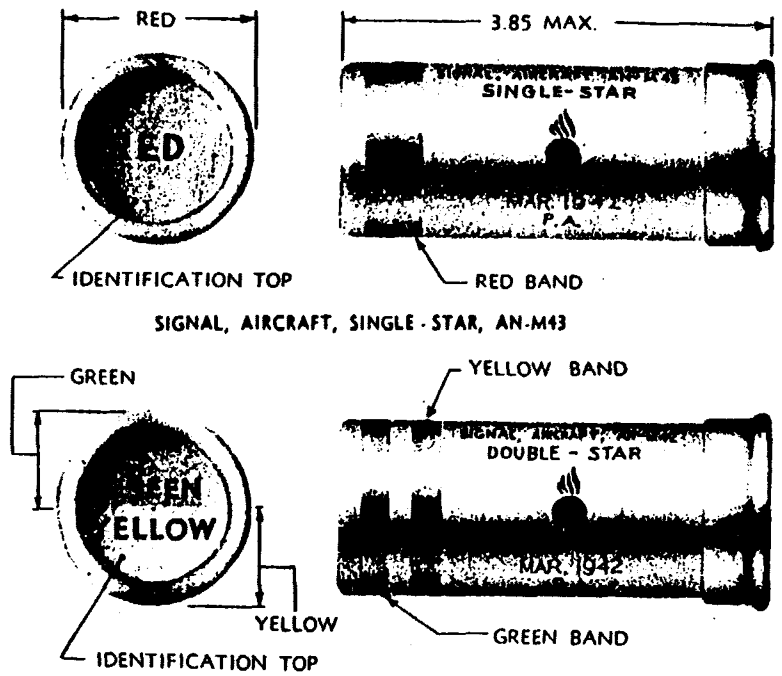
A—SIGNAL, AIRCRAFT, PARACHUTE, RED STAR, M11 — RED
B—SIGNAL, AIRCRAFT, SINGLE STAR, AN-M34 — RED
C—SIGNAL, AIRCRAFT, SINGLE STAR, AN-M35 — YELLOW
D—SIGNAL, AIRCRAFT, SINGLE STAR, AN-M36 — GREEN
E—SIGNAL, AIRCRAFT, DOUBLE STAR, AN-M28 — RED-RED

IDENTIFICATION TOP FOR: / COLOR

F—SIGNAL, AIRCRAFT, DOUBLE STAR, AN-M29 — YELLOW-YELLOW
G—SIGNAL, AIRCRAFT, DOUBLE STAR, AN-M30 — GREEN-GREEN
H—SIGNAL, AIRCRAFT, DOUBLE STAR, AN-M31 — RED-YELLOW
I—SIGNAL, AIRCRAFT, DOUBLE STAR, AN-M32 — RED-GREEN
J—SIGNAL, AIRCRAFT, DOUBLE STAR, AN-M33 — GREEN-YELLLOW
X—ALUMINUM (MARKING IN BLACK)

RA PD 61186A

Figure 112 — Aircraft Signals (Rimless Types)



NOTE:—COLOR OF BANDS AND IDENTIFICATION TOPS TO CORRESPOND WITH COLOR OF SIGNAL (SEE TABLE)

SIGNAL	COLOR OF BANDS AND IDENTIFICATION TOPS
AIRCRAFT, DOUBLE-STAR, AN-M37	RED - RED
AIRCRAFT, DOUBLE-STAR, AN-M38	YELLOW - YELLOW
AIRCRAFT, DOUBLE-STAR, AN-M39	GREEN - GREEN
AIRCRAFT, DOUBLE-STAR, AN-M40	RED - YELLOW
AIRCRAFT, DOUBLE-STAR, AN-M41	RED - GREEN
AIRCRAFT, DOUBLE-STAR, AN-M44	YELLOW
AIRCRAFT, DOUBLE-STAR, AN-M45	GREEN

RA PD 7210

Figure 113 — Aircraft Signals (Cartridge Type)

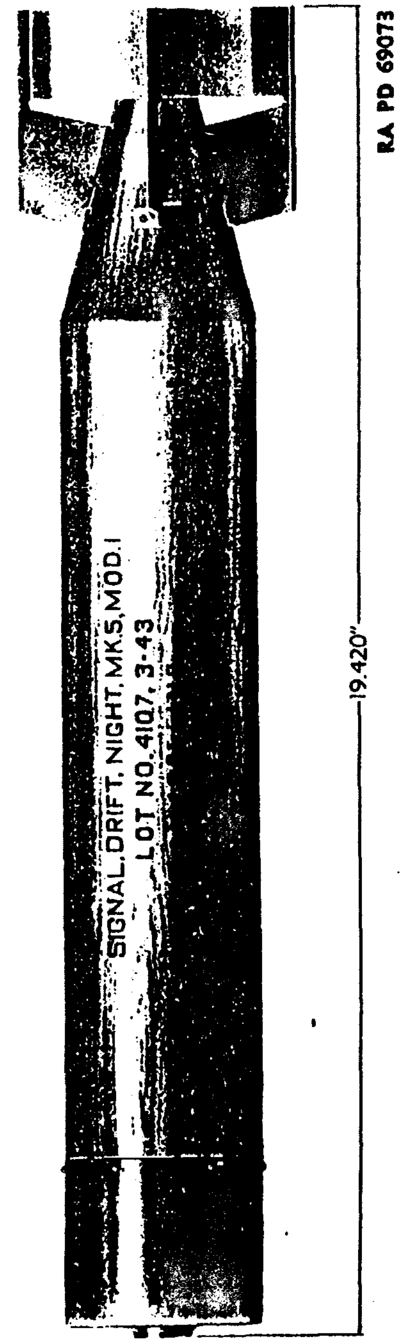
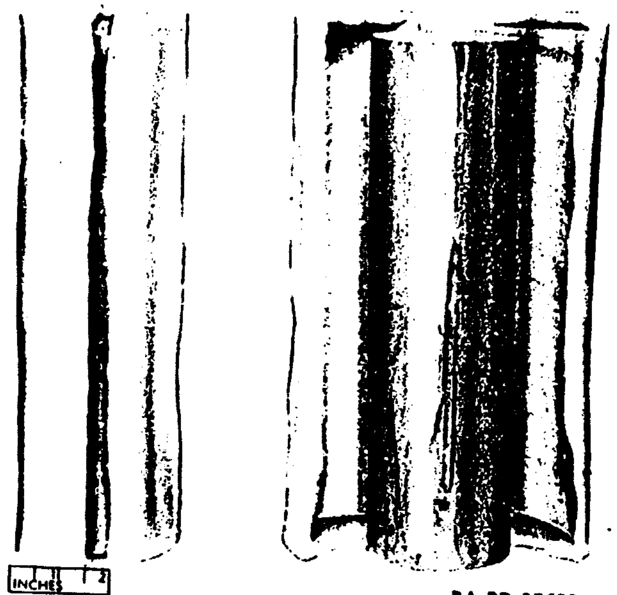


Figure 114 — Night Drift Signal AN-Mk 5 Mod 1



RA PD 35680

Figure 115 — Slick Marker AN-M59

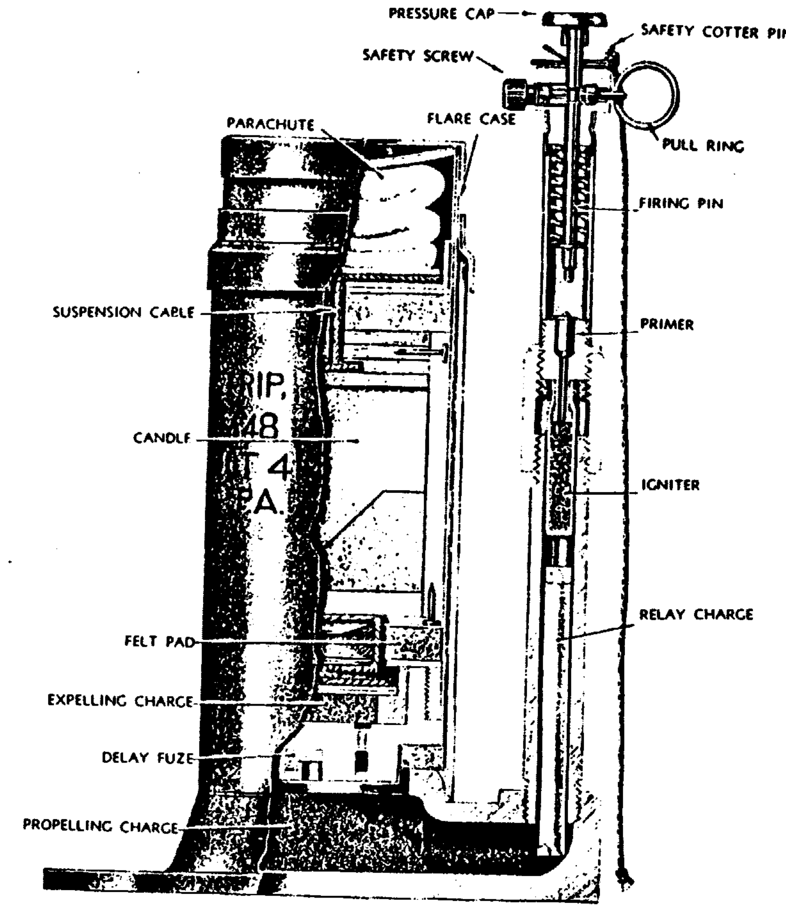
of its brilliant flash. The photoflash bomb M46 produces a flash which reaches an intensity of 500 to 700 million candlepower for approximately 0.02 second and functions from 5 to 90 seconds, depending on setting of its mechanical time fuze.

126. AIRCRAFT SIGNALS.

a. These signals are fired from pyrotechnic discharges which are described in TM 9-290. The signals are provided for signaling from aircraft to other aircraft or to ground units. They may also be fired on the ground. There are two types of aircraft signals:

(1) The rimless type, assembled in an aluminum or plastic-steel barrel. The barrel is in the shape of a cylindrical cup which is grooved near the base or closed end. The primer is pressed into the center of the base. A press fit identification top (closing top) is cemented in the opposite end. (See fig. 112.)

(2) The cartridge type, assembled in a cylindrical shell to which a metal or plastic head, containing the primer, is crimped. The opposite end is closed with a cardboard wad or press fit metal disc which is colored and marked to indicate type of signal. In appearance, it resembles a large shotgun shell (fig. 113).



RA PD 69071

Figure 116 — Parachute Trip Flare M48

127. DRIFT SIGNALS. Drift signals are provided as an aid to navigation over water by providing a stationary reference point for determination of drift of the airplane. The signals are released from the plane by hand and drop to the water, being stabilized in fall by fins. There are signals for daytime use and others for use at night. Day drift signals contain a metallic powder in a streamlined paper shell which breaks on impact with the water allowing the powder to form a slick on the surface for use as a reference point. Drift signals (fig. 114) for use at night contain a pyrotechnic pellet or candle which is ignited by the fuze on impact with water. The signal will

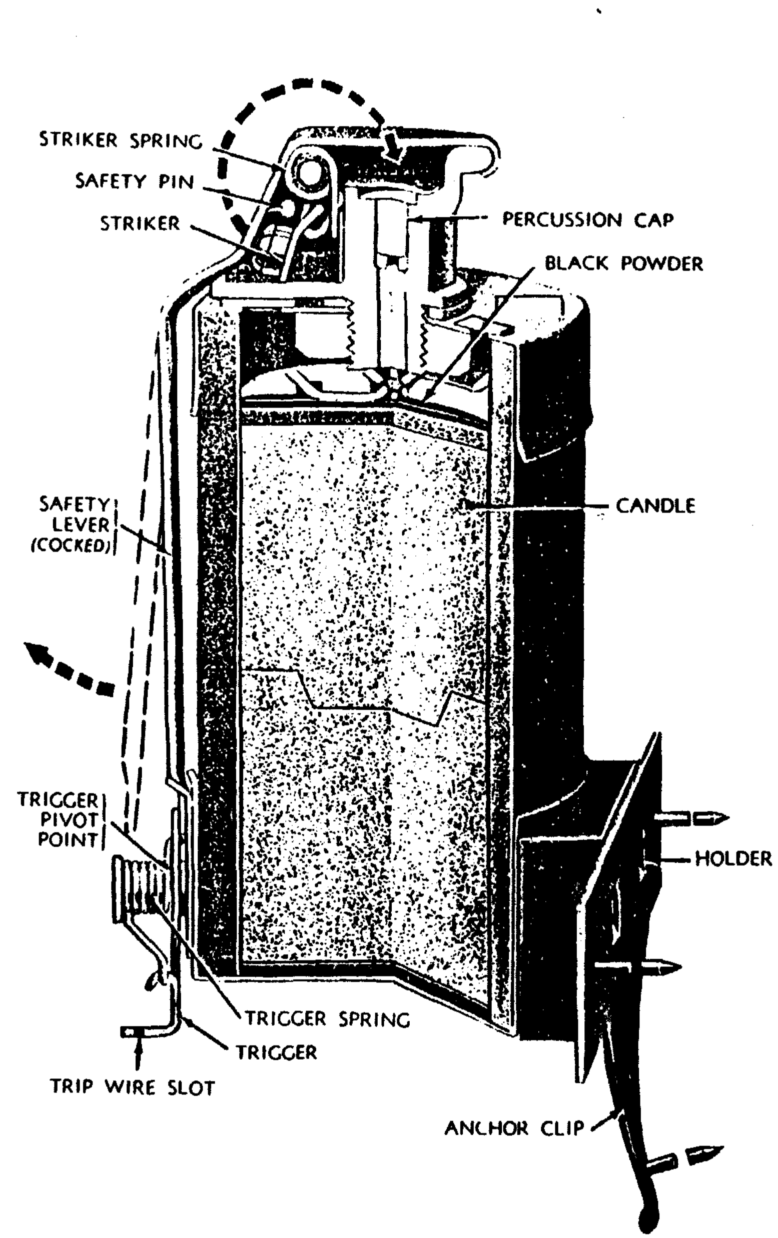


Figure 117 — Trip Flare M49

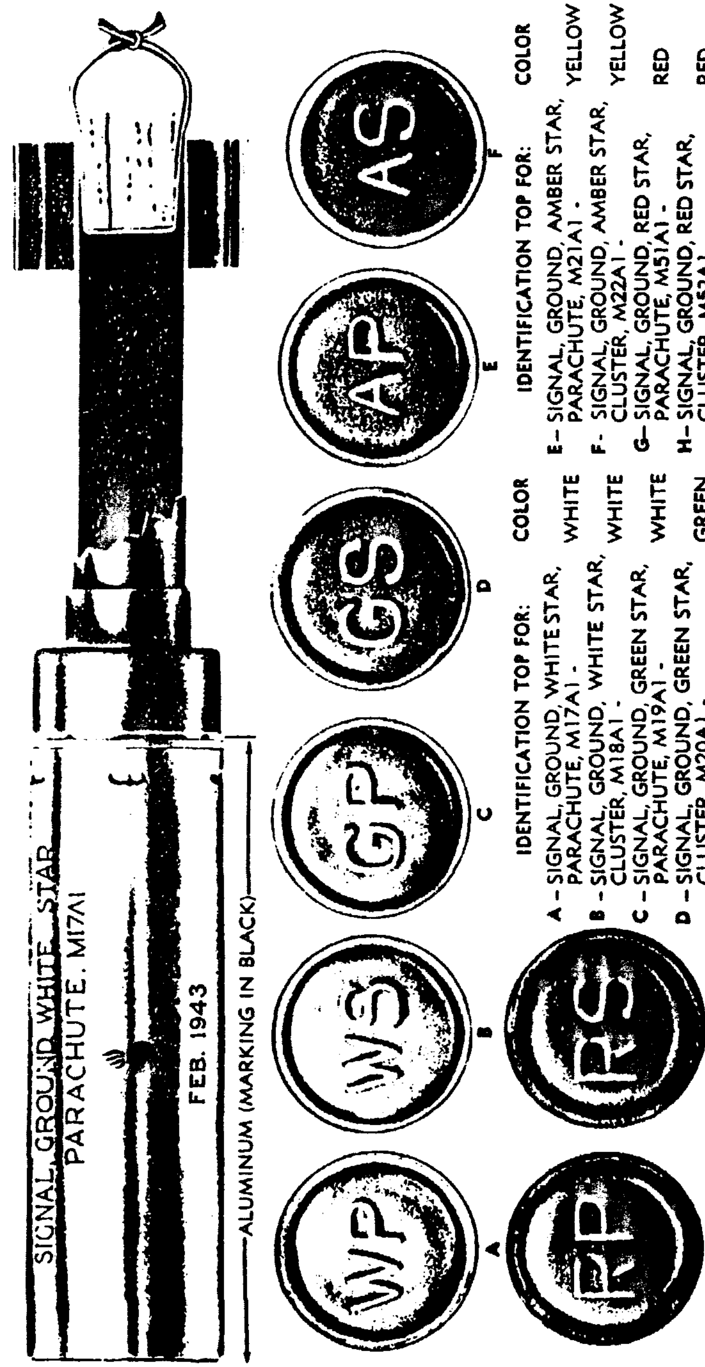
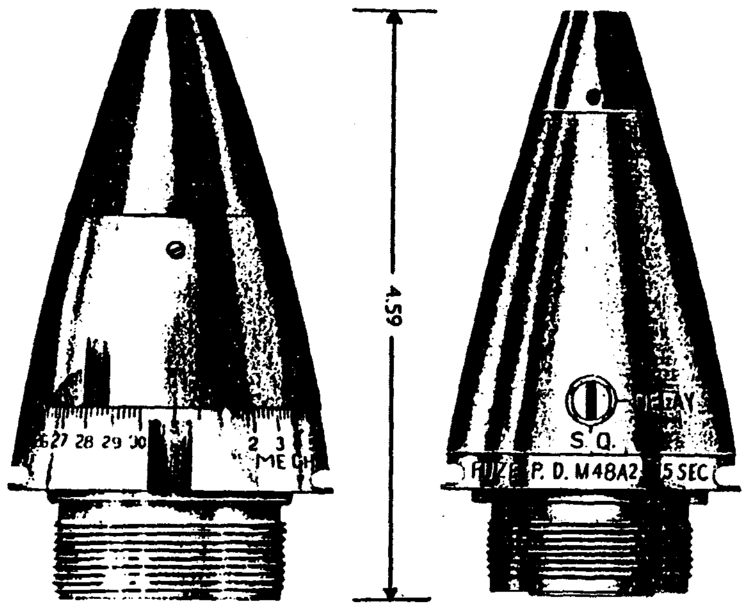
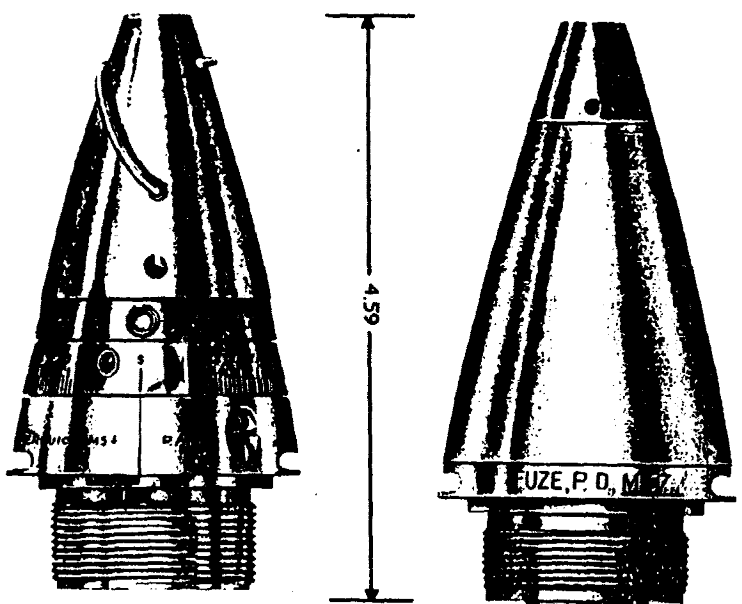


Figure 118 — Ground Signals — Launcher Type



M43 MECHANICAL TIME

M48A2 SQ AND 0.15-SEC. DELAY

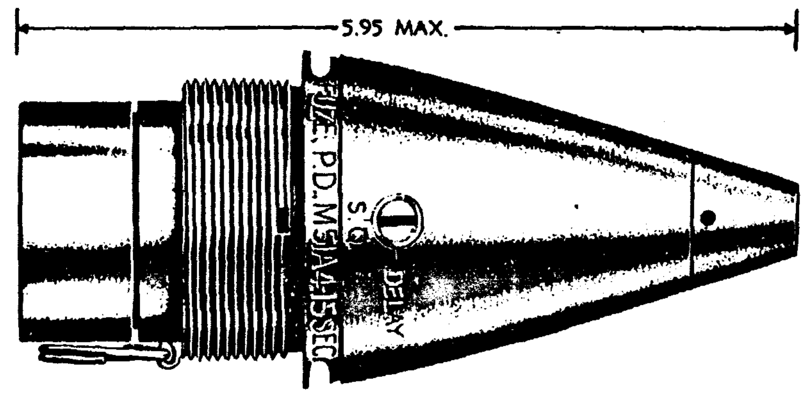


M54 TIME & SQ

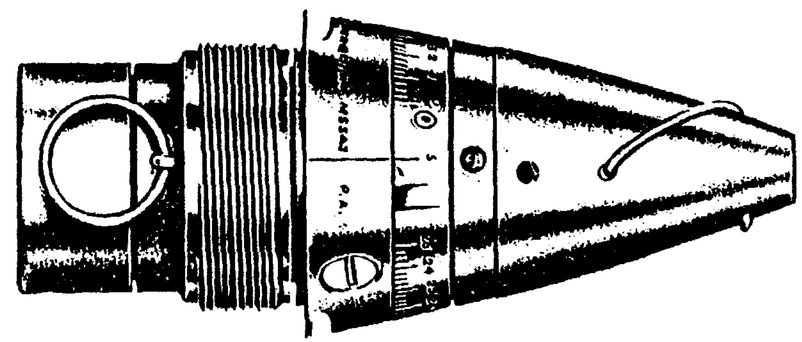
M57 SQ

RA PD 89326A

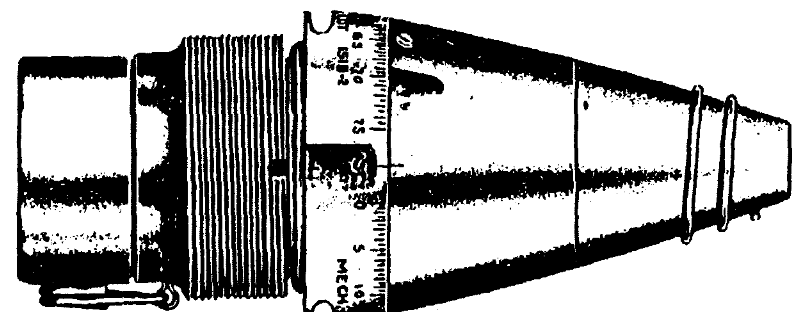
Figure 63 — Fuzes for Fixed and Semifixed Ammunition



M51A4 PD FUZE .15 SEC DELAY

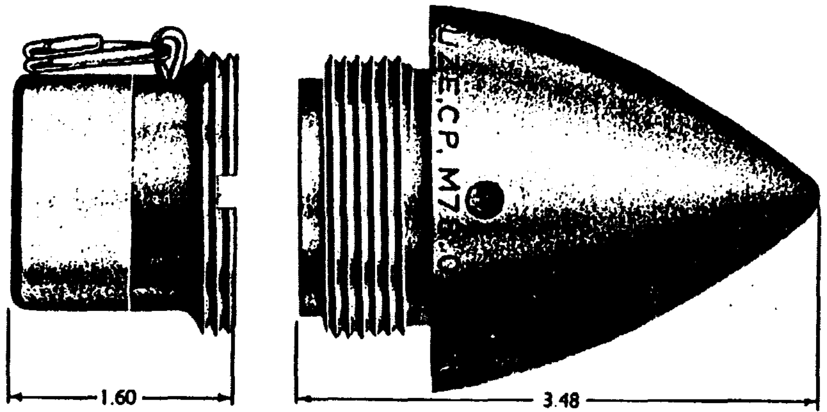


M55A3 TSQ FUZE



M67A3 MECHANICAL TIME FUZE RA PD 89322A

Figure 64 — Fuzes for Separate-loading Ammunition

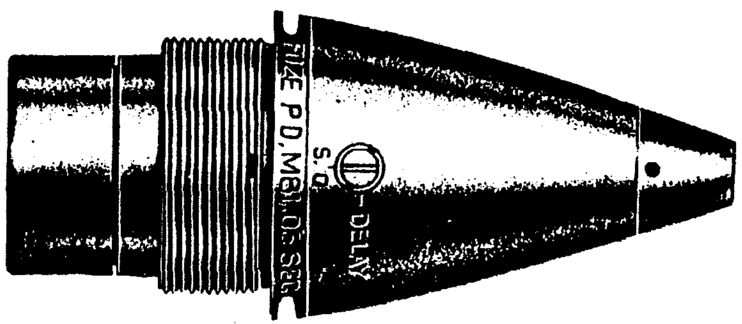


RA PD 104830

Figure 65 — Booster M25 and Concrete-piercing Fuze M78

malfunction.

(3) Fuzes of the impact type are armed by centrifugal or set-back force, or a combination of both, acting on parts of the fuze after the projectile leaves the muzzle of the gun. The time element of time fuzes is initiated at the instant of firing by set-back (that is, the effect of inertia). To prevent accidental arming in handling and shipping, safety devices such as a safety wire or cotter pin may be used. Such safety devices must be removed before firing.



RA PD 104831

Figure 66 — Rocket Fuze M81

102. ADAPTERS AND BOOSTERS.

a. **Adapters.** In chemical shell and in many high-explosive shell of large caliber, openings in the nose are considerably larger than required by the fuzes in order to facilitate the manufacture and loading of the projectiles. For such shell, a suitably threaded metal bushing, called an adapter, is necessary to reduce the size of the opening to conform to the threaded portion of the fuze. In chemical shell, the adapter has an additional function, that of providing a gas-tight seal for the chemical filler.

b. **Boosters.** The term "booster" is applied to the explosive element in the bursting-charge explosive train which detonates the main charge. The booster contains safety devices to prevent premature detonation of the main charge. The booster charge may be incorporated within the fuze itself. It is usually contained in a thin metal or plastic casing which is assembled to and handled as a unit with the fuze. It may be inserted in the shell during loading.

c. **Bursters.** An auxiliary explosive element in burster-type chemical shell, which opens the shell and disperses the chemical agent, is called a "burster." It consists of a burster charge, a container for the charge, and a metal head. The burster as used is contained in a burster casing in the shell.

d. **Adapter-boosters.** In some cases, the booster has been combined with the adapter, the two assemblies thereafter being handled as a unit. Such combinations are known as adapter-boosters. Adapter-boosters are not extensively used in present-day artillery shell.

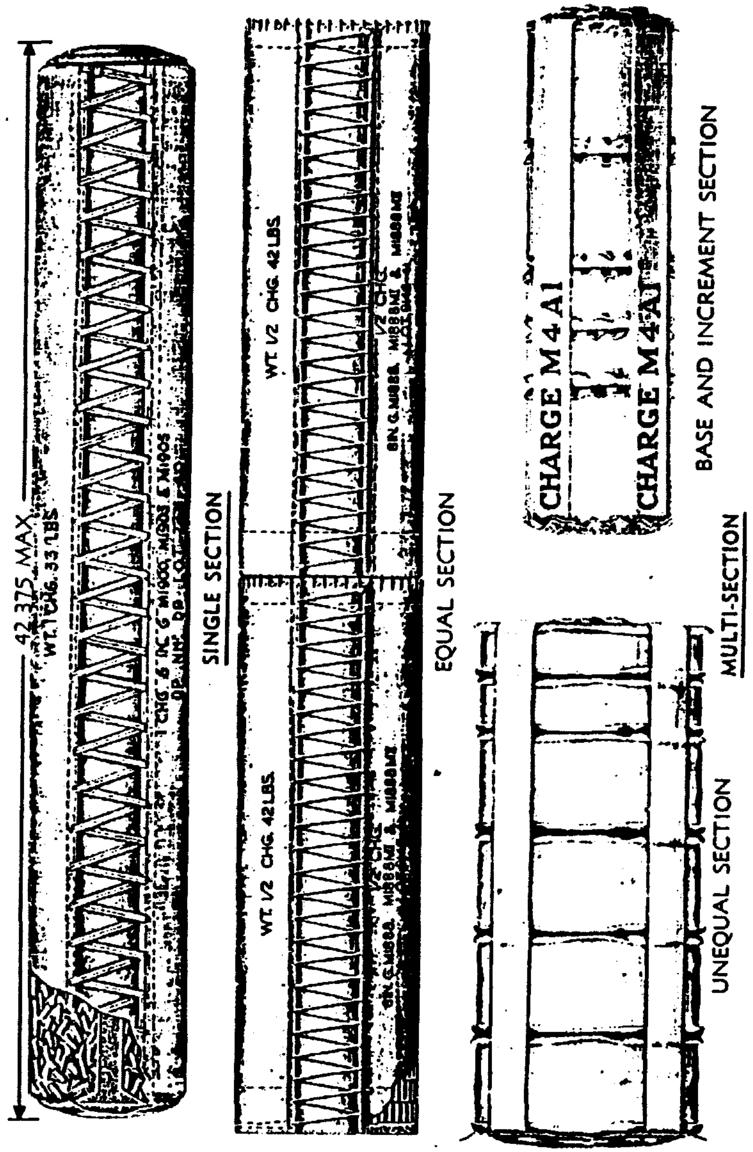
103. PROPELLING CHARGES.

a. **General.**

(1) In general, propelling charges consist of a charge of a propellant, with an igniter charge of black powder, assembled in a suitable cartridge case, cloth bag, or both.

(2) PROPELLENT POWDER. Propellants are described in chapter 1, section IV.

(3) IGNITER CHARGE. In fixed and semifixed rounds, the igniter charge of black powder is present in the artillery primer. In "separated" ammunition an auxiliary igniter charge is placed around the primer or on the distance wadding to insure proper ignition of the propellant. In separate-loading rounds, the igniter charge is assembled in an igniter bag sewed to the base end of the propelling charge and in some cases also forming a core running through the center of the propelling charge bag. Cartridge-igniter pads are made of closely woven silk to prevent the black powder from sifting through. Cloth of current manufacture used for the igniter charge is dyed red to indicate the presence of the black-powder igniter. That of earlier manufacture (undyed) is marked "IGNITER."



RA PD 89220

Figure 67 —Types of Separate-loading Propelling Charges

(4) TYPES OF PROPELLING CHARGE. The type of propelling charge depends upon the kind of ammunition, that is: fixed, semifixed, and separate-loading.

b. Fixed and semifixed charges.

(1) CARTRIDGE CASE. A cartridge case, made of drawn brass or steel, serves as the container for the propelling charge in the case of fixed and semifixed artillery ammunition. Its profile and size conform to that of the powder chamber of the weapon for which the case is intended. The head of the case is relatively thick and has a flange or groove to permit mechanical extraction. Rounds used in automatic guns have cartridge cases with an extracting groove instead of a flange or rim. The cartridge case holds the primer, propelling charge, and the projectile so that the assembly can be inserted into the weapon in one operation. It also provides for obturation, that is, it expands under the pressure of the burning propellent gases and prevents the escape of gas to the rear.

(2) PROPELLING CHARGE IN FIXED AMMUNITION. The propelling charge in a round of fixed ammunition is packed loosely in the cartridge case. In some instances where the charge does not fill the case completely, a spacer or distance wadding, usually a cardboard disk and cylinder, is inserted in the neck of the cartridge case, between the powder charge and the base of the projectile.

(3) PROPELLING CHARGE IN SEMIFIXED AMMUNITION. In semifixed artillery ammunition, the charge, divided into parts or increments for zone firing, is assembled in several cloth bags. The full charge with all increments in proper order, is assembled in the cartridge case, which is a free fit over the end of the projectile. Each increment is numbered, the base charge being numbered "1." Thus, to arrange a propelling charge in proper order for firing charge 4, the increments would be arranged in the order 1, 2, 3, and 4, increment 4 being placed uppermost.

c. "Separated" ammunition propelling charge. This propelling charge is contained in a cartridge case, together with the primer. The charge consists of propellent powder, loosely loaded in a brass cartridge case which is closed by a plug. It will be noted that this ammunition is considered to be separate-loading.

d. Separate-loading charges (fig. 67).

(1) CARTRIDGE BAGS. Cartridge bags form a suitable and convenient means of containing the smokeless-powder charge in separate-loading ammunition. Cotton cloth is the standard material for cartridge bags.

(2) SINGLE-SECTION CHARGES. Separate-loading propelling charges are divided into single-section and multisection charges. In the single-section charge, the propellent powder is contained in a single

bag, tightly laced or wrapped to give the charge rigidity. The igniting and end igniting charge is divided into three parts, each in its own bag, two end pads, and a core which extends axially through the center of the charge and connects the igniter pads sewed to each end. This type of igniter is termed a "core igniter."

(3) MULTISECTION CHARGES. Multisection charges permit the gun crew to vary the size of the propelling charge and facilitate handling the larger and heavier charges. Multisection charges are subdivided into "base and increment," "equal section," and "unequal section" types.

(a) Base and increment. This type of propelling charge consists of a base section or charge and one or more increments. The increments may be of equal or unequal weight. Whereas the base section is always fired, the increments may or may not be fired. With some types, one igniter pad is attached to the base end of the base section only, while other types have a core-type igniter in the base section and sometimes in one or more increments as well.

(b) Equal section. In this type, the sections are equal in size and weight. It was formerly known as the "aliquot part" charge. It is used in 14-inch gun ammunition and for other larger-caliber weapons.

(c) Unequal section. In the case of certain howitzers, the charge is made up in unequal sections. In the case of guns, the charge may be made up of several equal sections and two or more unequal sections. This type permits firings at reduced velocities and provides the maximum flexibility.

(4) COLOR. In certain cases two base and increment charges are provided for one howitzer—one for inner, the other for outer zones of fire. The cloth of the bags for the inner zones is dyed green to distinguish that charge from the other type which is assembled in undyed (white) bags. Accordingly, these two types of charges are called "green bag" and "white bag" charges (fig. 6).

(5) STACKED CHARGES. In order that certain long propelling charges will have more rigidity, the grains of powder are arranged or stacked in uniform order and direction. These charges, having the grains with their long axis parallel to the longitudinal axis of the charges, are said to be "stacked."

(6) FLASH REDUCERS. Flash reducers are used with propelling charges during night firing. These devices greatly reduce the flash and thereby impede enemy observation of gun positions. The flash reducer developed for the 155-mm guns (fig. 68) consists of two scarlet-dyed cotton strips which are linked together with silk strings. Each strip contains three channels which are filled with chemicals. Two outside channels of each strip contain a mixture of 60 percent potassium sulfate and 40 percent black powder. The center channel contains only black powder. When tied around the charge, the

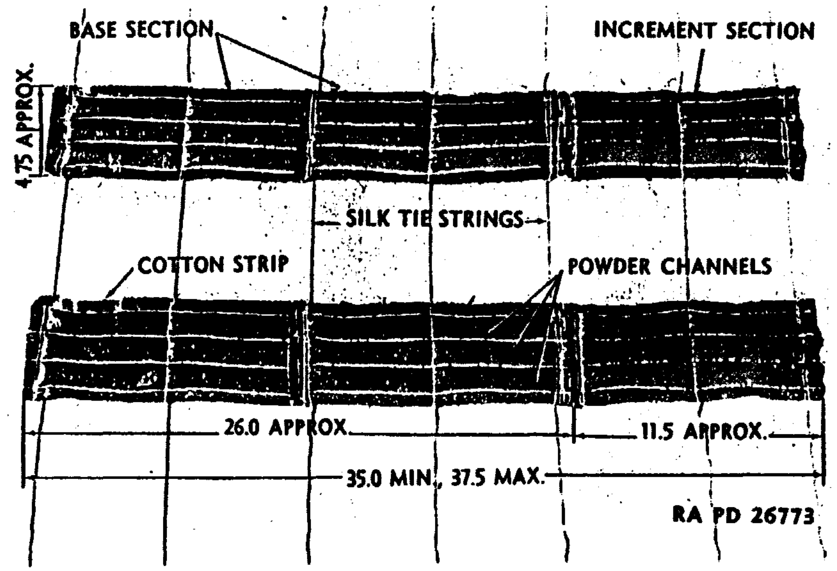


Figure 68 — Flash Reducer for Propelling Charges for 155-mm Guns

strips are opposite each other. Flash reducers are made to fit a specific propelling charge. The use of flash reducers slightly increases the muzzle velocity; therefore, the proper correction must be applied when computing range data during firing.

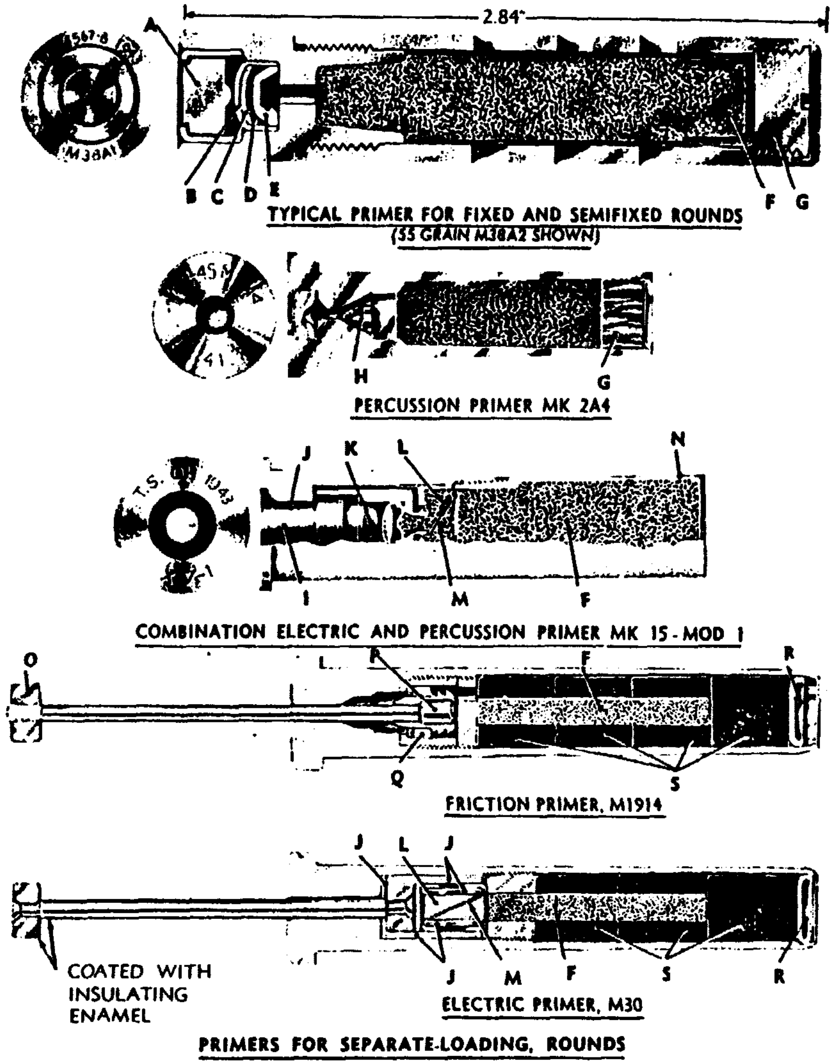
(7) DUMMY CHARGES. Dummy charges, simulating service charges (fig. 62), are provided for use with drill projectiles to train personnel in "service of the piece."

104. PRIMERS.

a. General. A primer is the component used to initiate the combustion of a propelling charge. Artillery primers (fig. 69) consist essentially of a small quantity of sensitive explosive and a charge of black powder, encased in a metal container. In the case of fixed and semifixed ammunition, the primer is forced into the base of the cartridge case at time of manufacture. In the case of separate-loading ammunition, the primer is inserted by hand into the breechblock of the weapon.

b. Types. Based on the method of firing, artillery primers are classified as percussion, electric, combination percussion-electric, friction, and ignition.

c. Percussion primer. This type of primer, fired by a blow of the firing pin, is generally used in all artillery ammunition except that for harbor defense and railway artillery. The primers used in



A — FIRING PLUG
B — PRIMER CUP
C — PERCUSSION ELEMENT CHARGE
D — FOILING PAPER
E — ANVIL
F — IGNITER CHARGE *(PRIMER CHARGE)*
G — BODY PLUG
H — CONICAL GAS CHECK
I — FIRING PLUG
J — INSULATOR
K — PLUNGER
L — GUN COTTON
M — CONTACT OR IGNITION WIRE
N — METALLIC SEAL
O — BUTTON
P — SERRATED GAS CHECK
Q — FRICTION COMPOSITION
R — CLOSING CUP
S — PRESSED BLACK POWDER PELLETS

RA PD 89324A

Figure 69 — Primers — Sectioned

cartridge cases contain sufficient black powder to ignite properly the smokeless powder in the cartridge case. Those used with separate-loading propelling charges contain only enough black powder to ignite the black-powder igniter charge attached to the propelling charge.

d. **Electric primer.** This type of primer is fired by the heat generated when an electric current passes through a resistance wire embedded in dry guncotton. It is used only in harbor defense and railway artillery. Although both the friction and electric primers are very similar in appearance, the electric primer is distinguished by black insulation around the contact wire and by a groove machined around the head.

e. **Combination percussion-electric primer.** This primer is fired either electrically or by a blow of the firing pin. It is used only in certain harbor defense and railway artillery.

f. **Friction primer.** This type of primer is fired by the heat generated when a serrated plug is pulled through an explosive composition sensitive to heat or friction. At the present time it is used as a substitute for the electric primer in the event of failure of electric power.

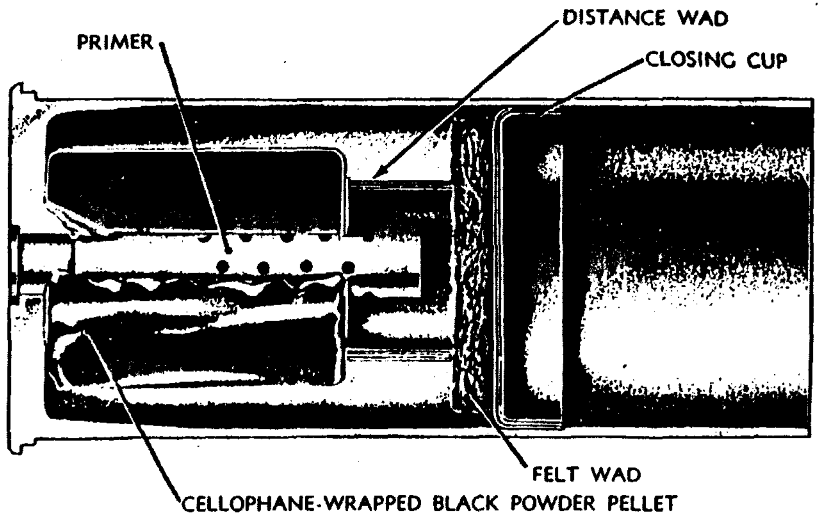
g. **Ignition primers.** The ignition primer, although very similar to the percussion type, differs in that it contains, in lieu of the percussion element, an inert cap with a hole in it. It is intended for use in certain subcaliber ammunition fired by a service primer. The flame from the service primer passes through the hole in the cap of the ignition primer, thus igniting the black-powder charge in the ignition primer.

105. BLANK AMMUNITION.

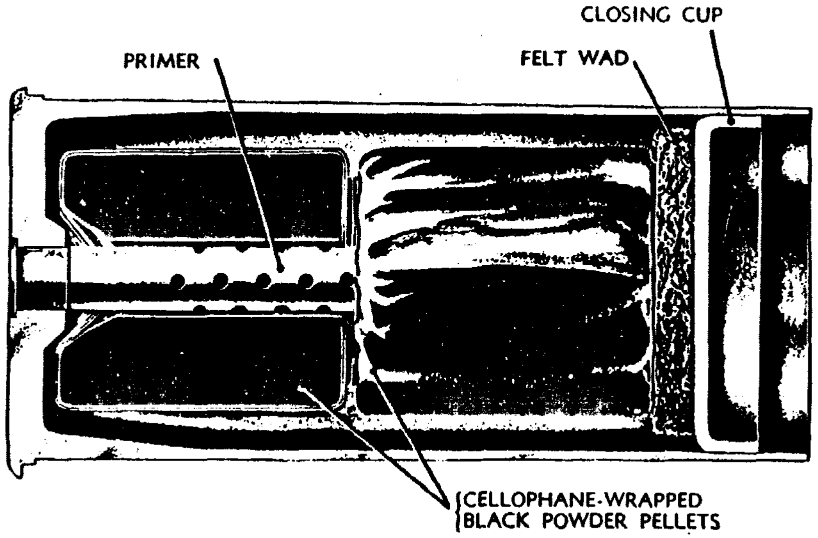
a. **General.** Blank ammunition is provided for cannon of caliber up to and including 105-mm, for practice purposes, for maneuvers, for firing the morning and evening gun, and for saluting.

b. **Complete round.** A complete round of blank ammunition (fig. 70) consists of a cartridge case into which are fitted a percussion primer, a charge of black powder, and a chipboard closing cup sealed in the mount of the case. The cartridge case is usually made by trimming service cartridge cases to the proper length. The black-powder charge in the latest design of blank ammunition consists of a single or double pellet in place of the loose black powder (in bag) formerly used. A hole, into which the primer extends, is left in the center and the pellet is wrapped in cellophane.

106. POWDER TEMPERATURE INDICATORS. Powder temperature indicators (fig. 71), used in antiaircraft batteries, enable taking the powder temperatures for ammunition either at battery or in storage at points of supply. They consist of a thermometer



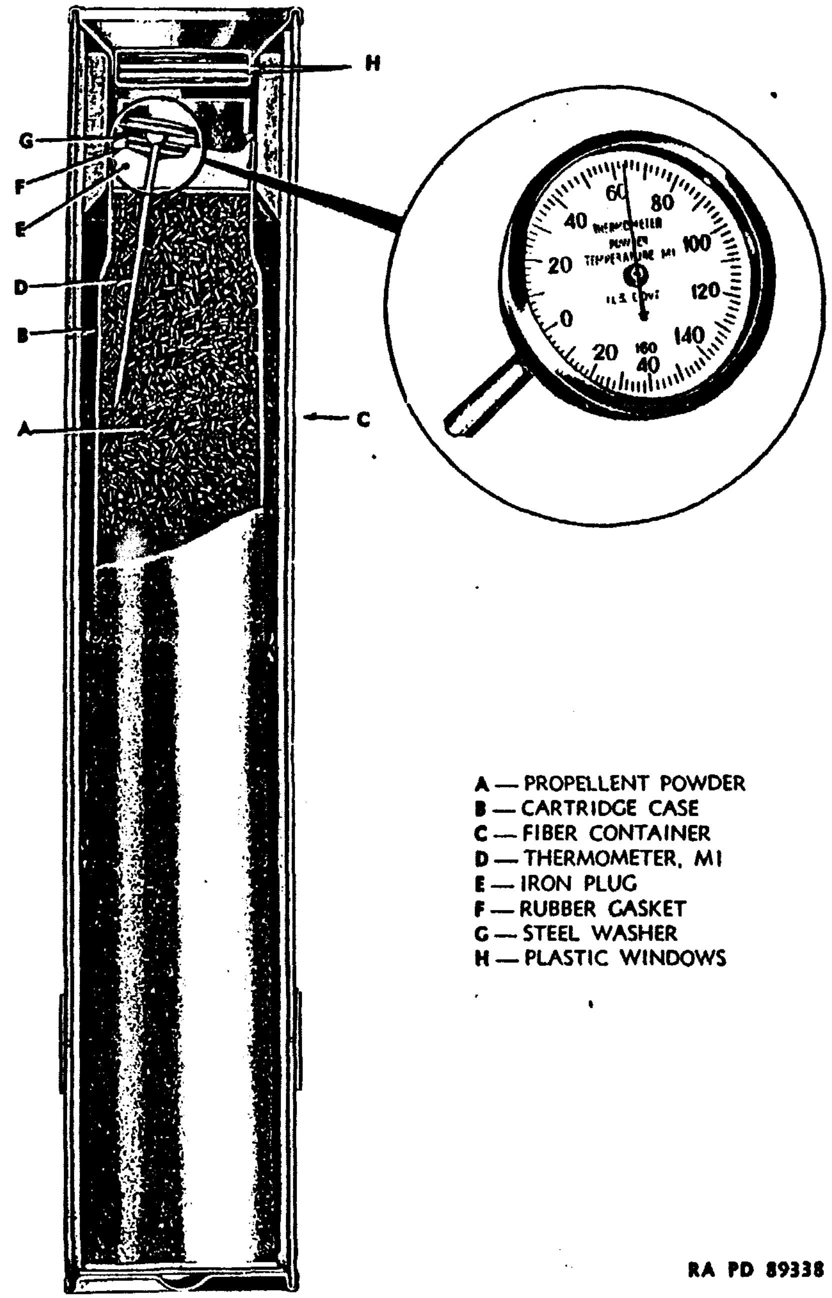
BLANK AMMUNITION (SINGLE PELLET CHARGE), 75-MM GUN OR HOWITZER



BLANK AMMUNITION (DOUBLE PELLET CHARGE), 75-MM GUN OR HOWITZER

RA PD 89316

Figure 70 — Blank Ammunition — Single and Double Pellets



RA PD 89338

Figure 71 —Powder-temperature Indicator

stuck into a powder charge in a service cartridge case which, in turn, is packed in a fiber container. The thermometer can be read through plastic lenses placed in the head of the assembly. They are placed with the lot of ammunition so that the temperature may be noted. Since firing tables are based on the temperature of the powder at 75° F at the time of firing, any deviation from this temperature has to be considered in firing data computations.

107. CARE AND PRECAUTIONS IN HANDLING.

a. In addition to the precautions prescribed in chapter 3, the following will be observed:

(1) PROJECTILES. Projectiles should be inspected to insure that there is no exudation of the contents, that the bourrelet and rotating band are smooth and free from serious dents or burs, and that the threads of the adapter are clean. Field artillery projectiles should be clean and free from grease.

(2) PROPELLANTS. The propellants of fixed ammunition cannot be readily inspected, but those for other ammunition should be noted when preparing the charge. Make certain that only the proper increments are removed from the adjustable complete charge. There should be no leakage of contents from any of the cartridge bags. For separate-loading ammunition, the tag and igniter pad cover, if present, must be removed prior to loading the charge into the weapon.

(3) FUZES. The fuze should be carefully inspected to ascertain that it is properly set, and that no unauthorized removal of parts has been made. No attempt will be made to disassemble fuzes or rounds in the field without specific instructions from the Chief of Ordnance. All separately-issued fuzes should be tightened to the projectile with a fuze wrench. With fixed and semifixed ammunition, the packing stop must be removed from the projectile before firing. Time fuzes which have been set but not fired must be reset at "safe" before being replaced in their containers.

(4) PRIMERS. Because of the hygroscopic nature of primers, their container cans should not be opened till necessary. Primers should be inspected particularly for signs of corrosion.

(5) CARTRIDGE CASES. Cartridge cases should be carefully inspected for cracks or dents which may affect their functioning or the functioning of the weapon. Badly corroded cartridge cases will increase the difficulty of extraction or may result in split or ruptured cases. Cases with faults which may result in a rupture should not be used. Their use may place a weapon out of action for a considerable period of time while the ruptured case is being removed. With semifixed ammunition, it is important that the mouths of cases not be deformed. If deformed, such a case may be difficult to load and, if loaded and fired, a serious blow-back may result.

RA PD 104832

Figure 72 — Metal Container for Primers

108. PACKING.

a. **General.** Artillery ammunition and components, except separate-loading projectiles, are packed in moisture-resistant fiber containers which are boxed (figs. 73 and 74) or placed in metal containers or in sealed metal cans. Crates may be used for additional protection for certain cartridge-storage cases (metal containers for propelling charges), projectiles having windshields, and dummy projectiles. Some fuzes are now being packed in hermetically sealed cans and then in a wooden box (fig. 76). Separate-loading projectiles are shipped boxed, crated (fig. 75), or uncrated. If uncrated, a grommet is placed around the rotating band and an eyebolt-lifting plug is screwed into the fuze hole (figs. 57 and 58).

b. **Metal containers.** Airtight cylindrical metal containers, known as cartridge-storage cases (fig. 8) are used to pack separate-loading propelling charges. Similar metal containers (figs. 78, 79, 80, and 81) are also used to pack one artillery round, either with or without a fiber container. The metal container has a detachable screen-type cap. To insure compact and tight packing, rubber felt and cork pads

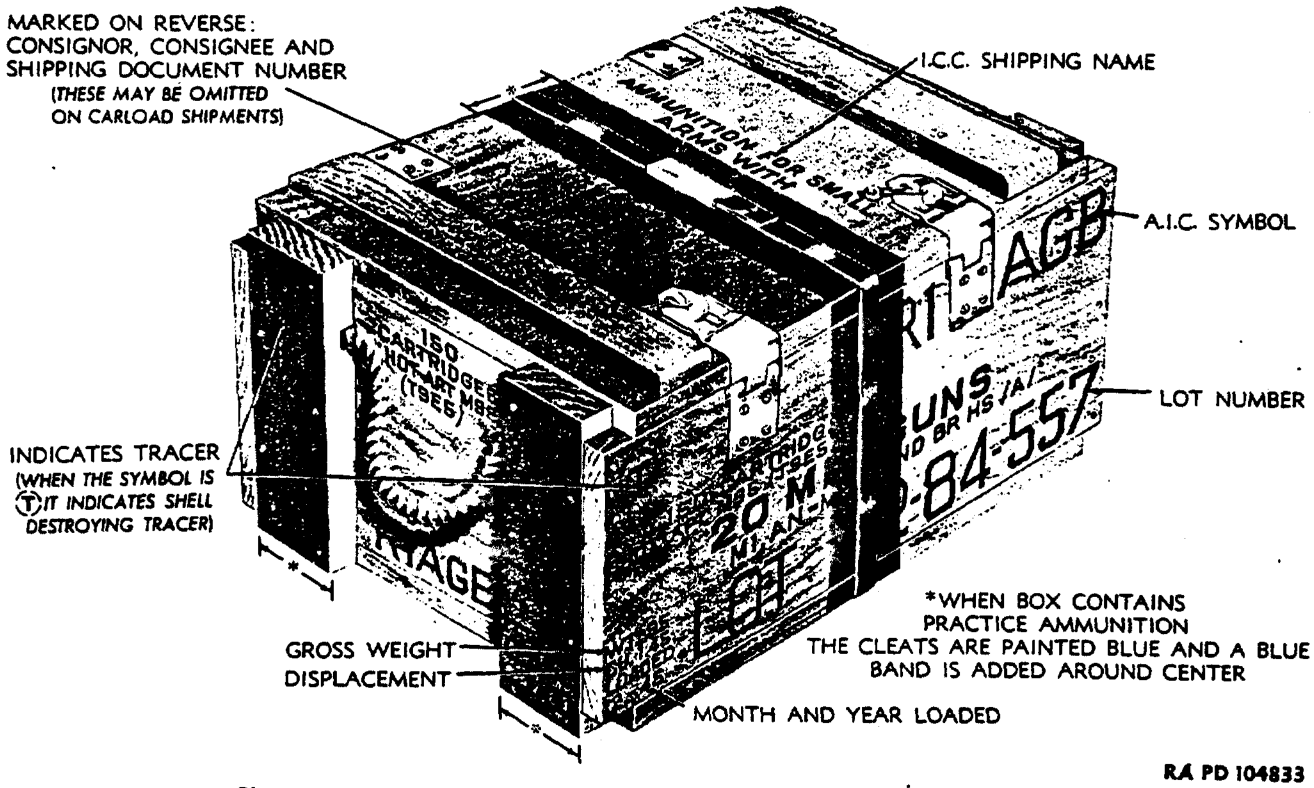


Figure 73 — Typical Packing Box for Small-caliber, Fixed Ammunition

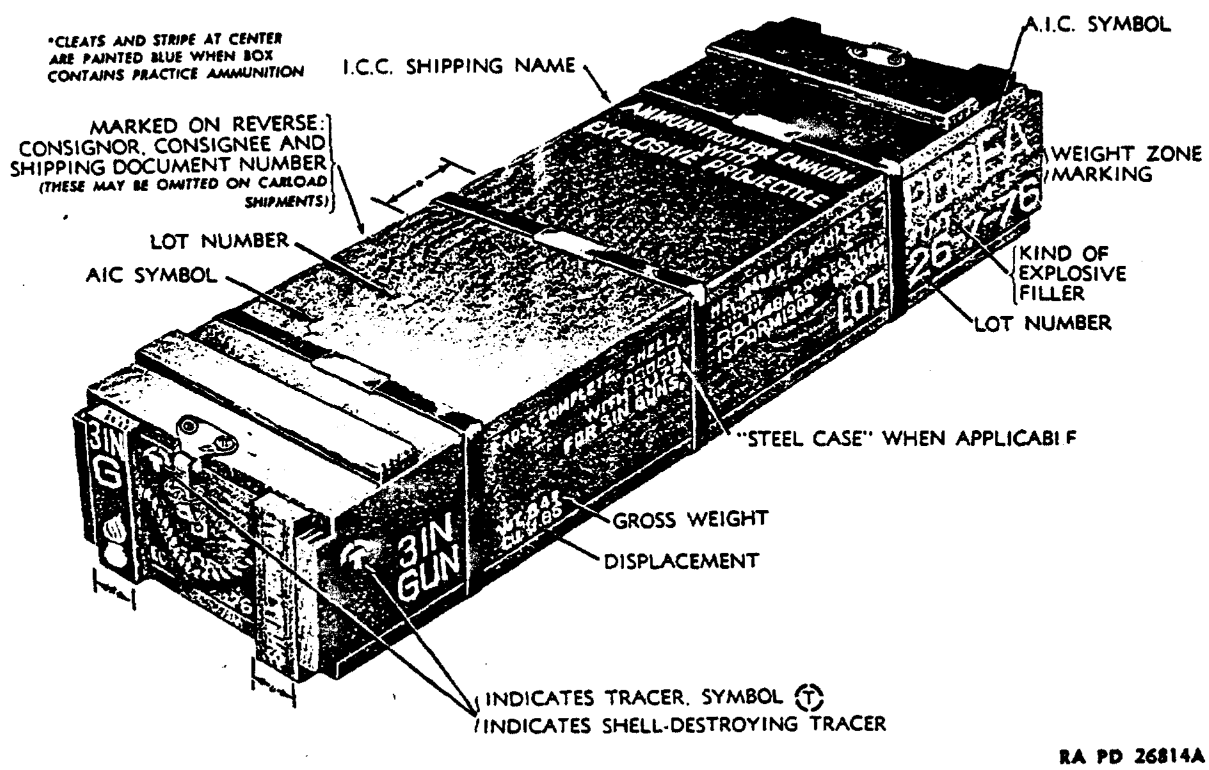


Figure 74 — Typical 2-round Packing Box

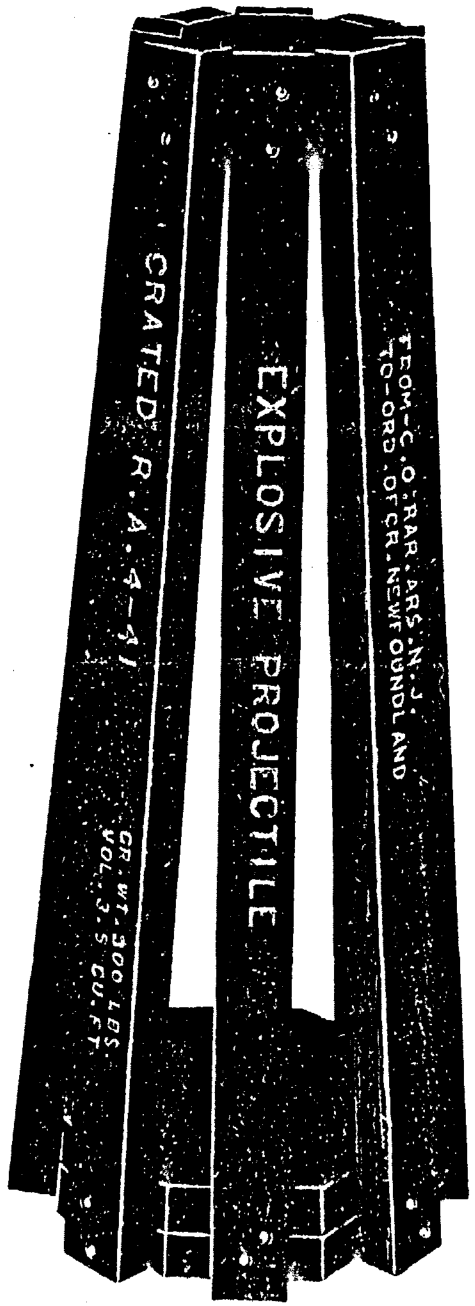


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Figure 75 — Typical Wooden Packing Crate for Separate-loading Projectile

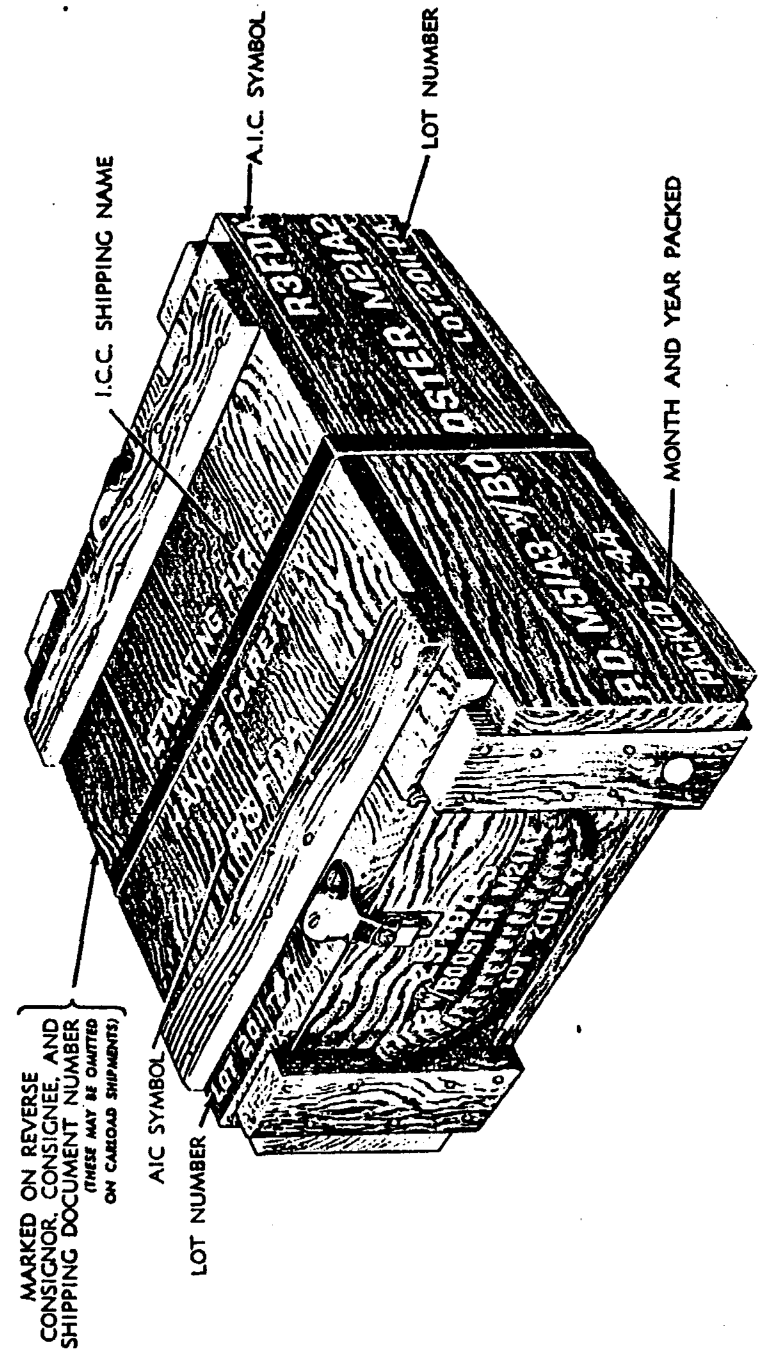

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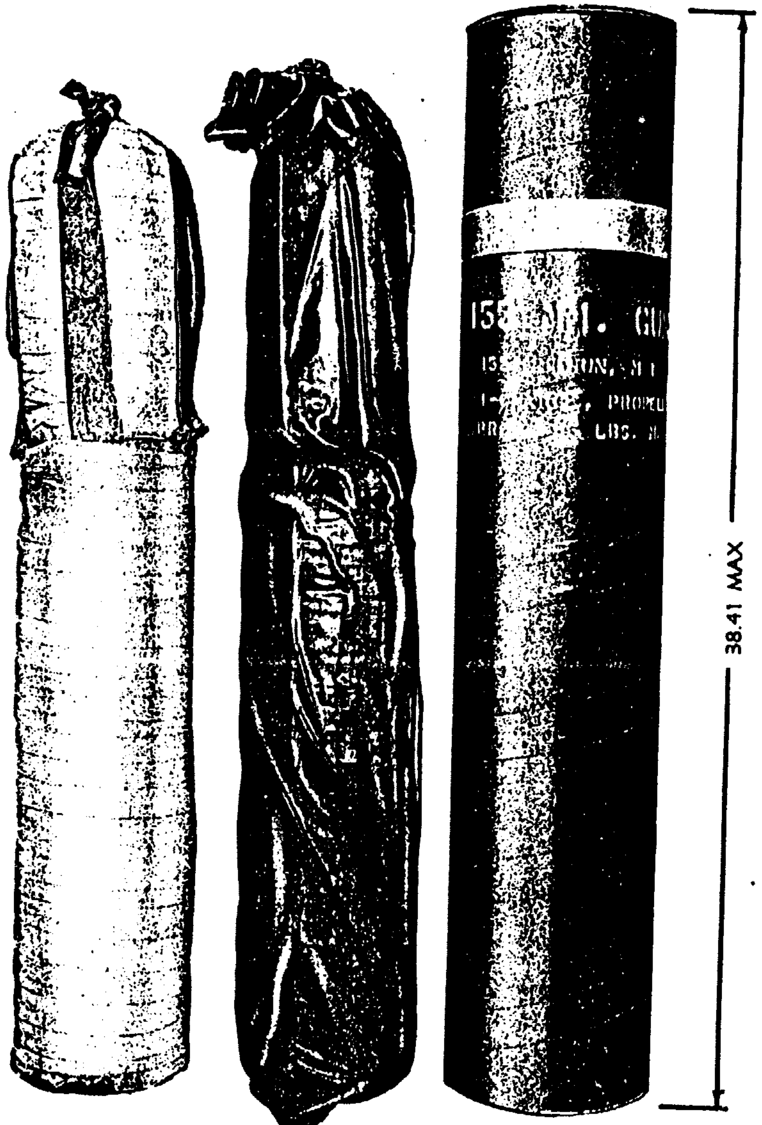
Figure 76 — Typical Packing Box for Fuzes



A B C

A — SEPARATE-LOADING PROPELLING CHARGE
B — CHARGE IN WATERPROOF BAG
C — FIBER CONTAINER - OUTER PACK

RA PD 97755

Figure 77 — Propelling Charge Packed in Waterproof Bag in Fiber Container

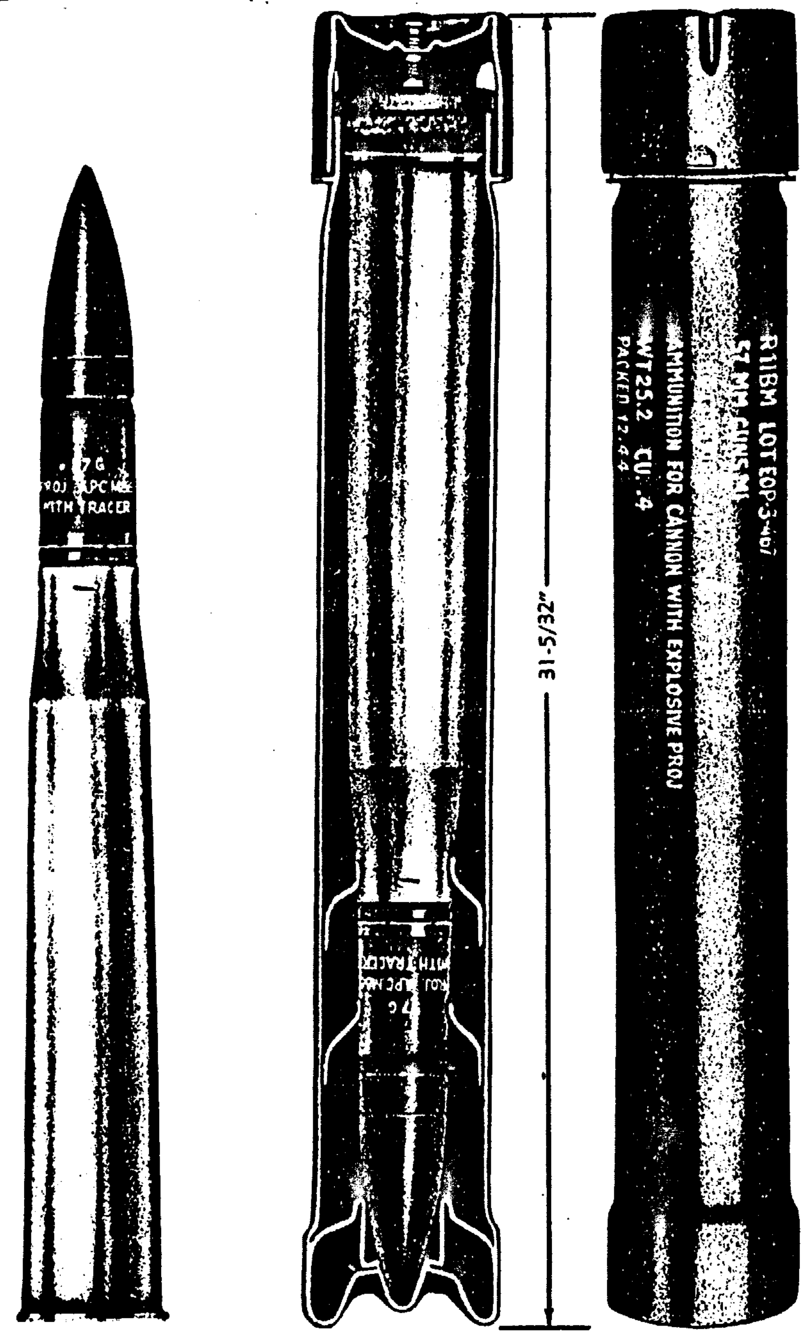


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Figure 78 — Metal Container M175 for 57-mm APC-T Rounds

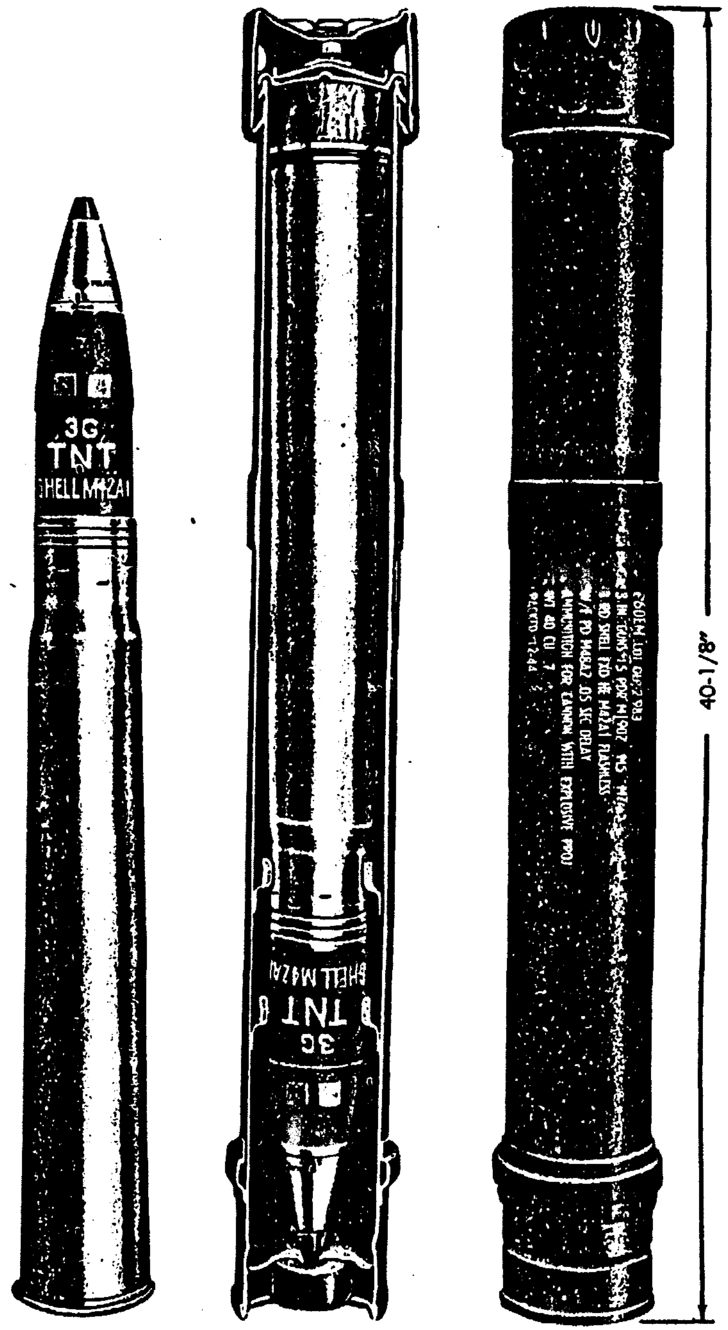

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Figure 79 — Metal Container M158 for 3-inch Gun Rounds

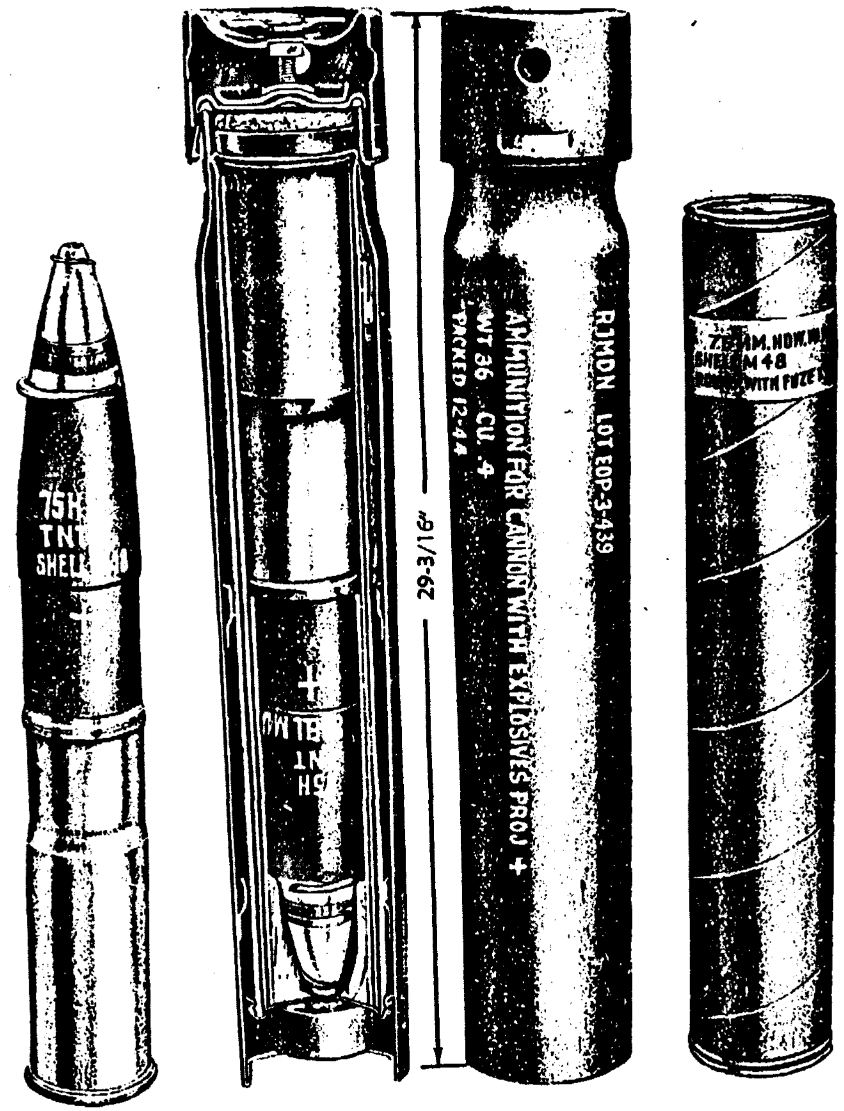

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Figure 80 — Metal Container M173 for 75-mm Howitzer Rounds

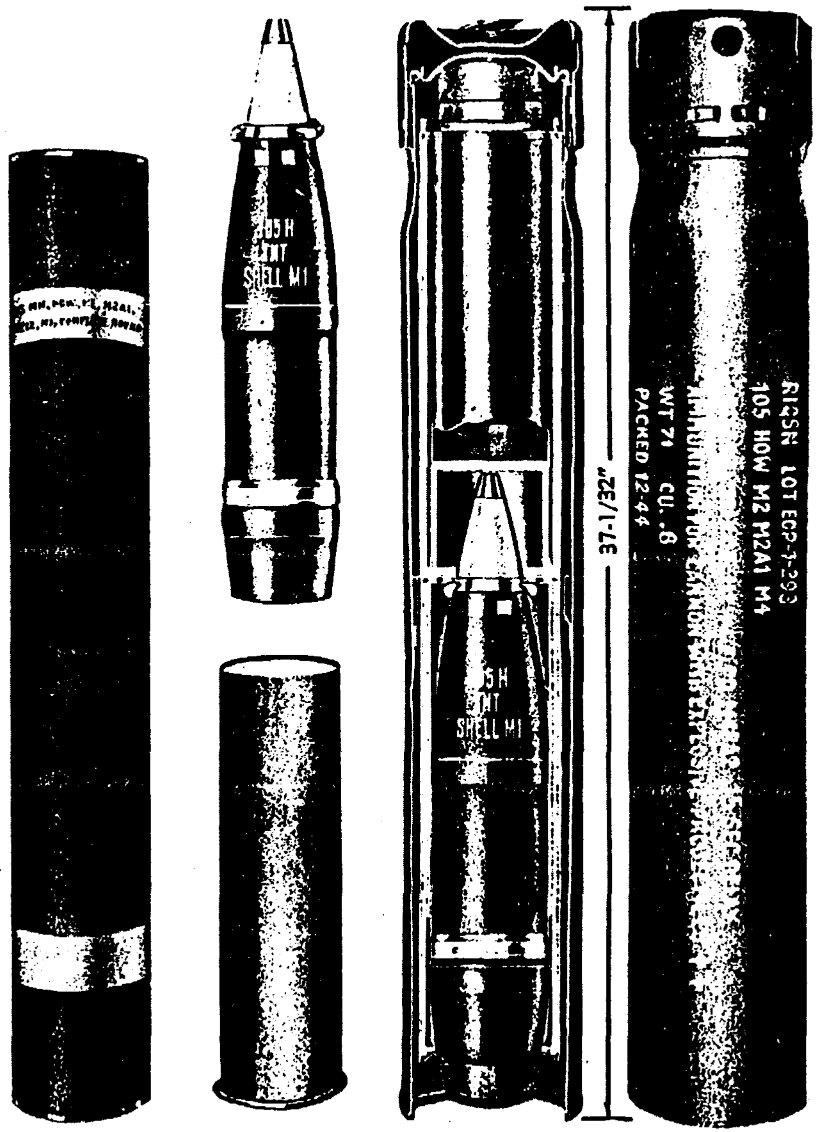

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Figure 81 — Metal Container M152 for 105-mm Howitzer Rounds

are used in the interior of the container to prevent sideward motion, upper and lower guide rings are provided on the interior of the container.

c. **Metal cans.** A sealed metal can (fig. 72) with metal tear strips is used to pack separate-loading artillery primers. These cans are packed, in turn, in a wooden box.

d. **Waterproof bags.** Propelling charges may be packed in waterproof bag in fiber containers (fig. 77).

Section V

BOMBS

109. GENERAL.

a. A bomb is a stream-lined container of explosives or chemicals intended for release from aircraft. It consists of a body containing the charge and a device to explode or scatter the charge at the target. Aircraft torpedoes, submarine mines planted by aircraft, rockets, pyrotechnics, and mortar bombs, although similar in nature, are not classified as bombs.

b. For reasons of safety, the components of a bomb are usually stored and shipped separately, and must be assembled prior to use. The components of bombs (fig. 82) differ (depending on the particular type and model) but, in general, they consist of:

(1) The unfuzed bomb body containing explosive, incendiary, or chemical filler.

(2) The fuze, or fuzes.

(3) The fin assembly (assembled to smaller bombs as shipped).

(4) The arming wire assembly.

c. Bombs are installed in airplanes by means of suspension lugs. Bombs of 100 pounds and more have the suspension lugs on the side of the body, arranged for horizontal suspension of, the bomb. Some smaller bombs have one lug on the side and another on the tail end, which permits the bomb to be installed either in a horizontal or vertical bomb rack; others are strapped in clusters of several bombs and suspended as a unit. Some AN bombs have three suspension lugs, two on one side of the bomb body and one on the opposite side to provide for use in both Army and Navy aircraft.

d. The functioning of bombs depends primarily upon the action of the fuze, which may be superquick, delay, or time. The terms "superquick" (instantaneous) and "delay" refer to the action at the instant of fuze impact, whereas "time" refers to the time from the release of the bomb to the instant of function.

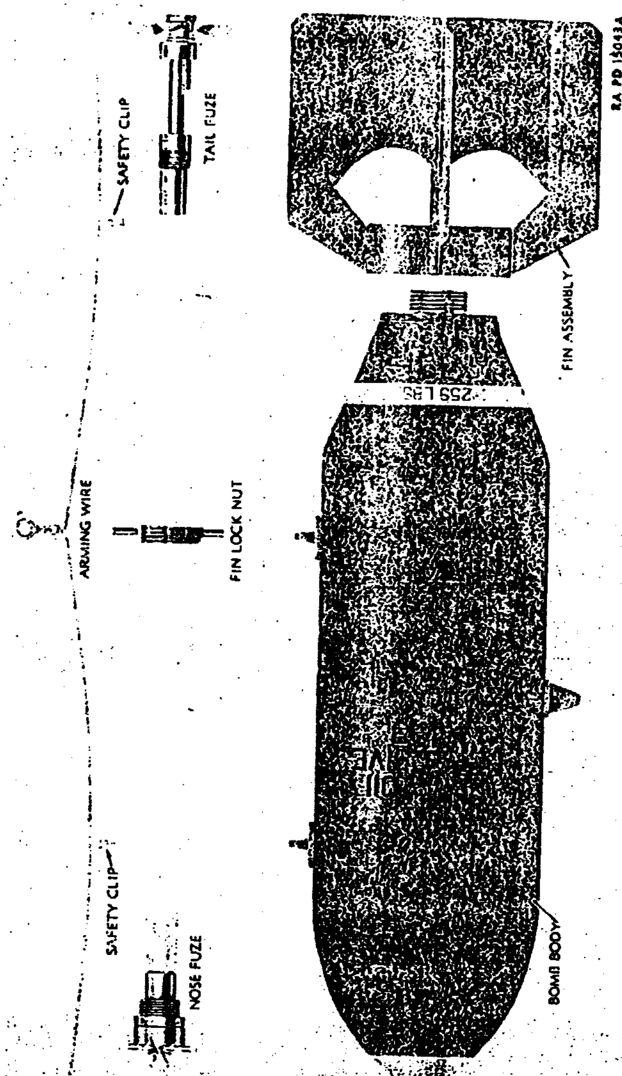


Figure 82 — Components of Bombs

e. Bomb fuzes, after assembly into the bombs, are prevented from arming or functioning during handling by means of an arming wire which is normally removed by the bomb's release from the airplane. When it is necessary to remove the arming wire to unfuze a bomb, instructions attached to the fuze should be followed closely. Provision is made for releasing the bomb "safe" from the airplane without removing the arming wire from the fuze when it is desired that the bomb should land without functioning.

f. A general description of the several types of bombs is included in the following paragraphs.

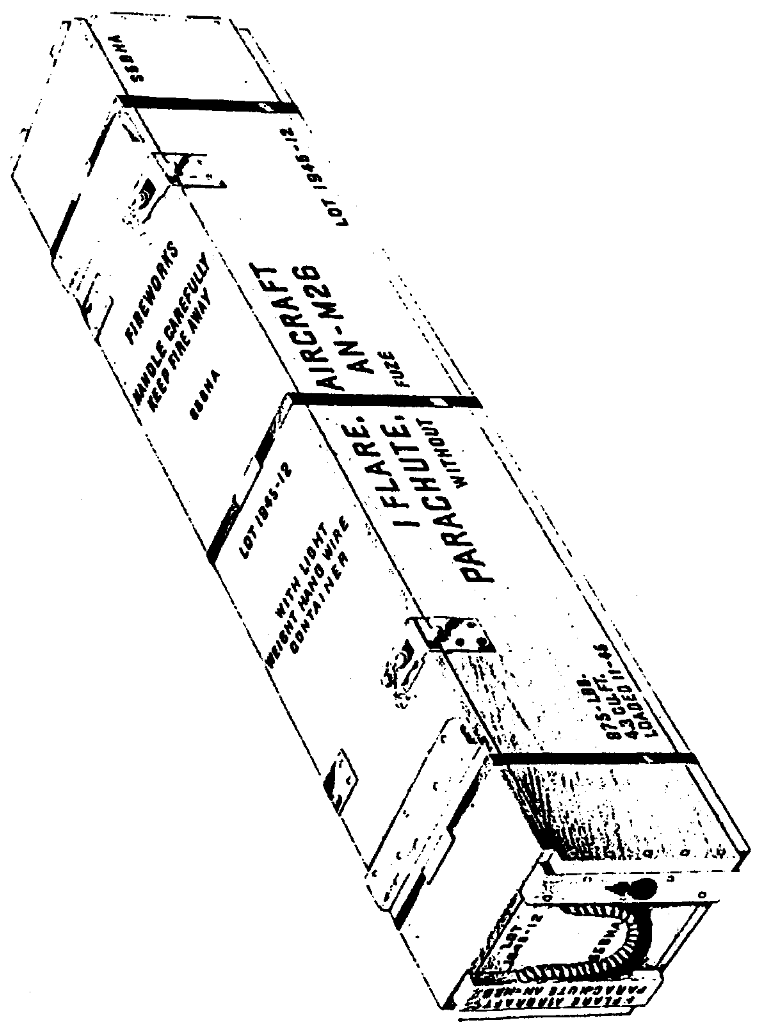
110. IDENTIFICATION. Bombs are painted in accordance with the basic color scheme outlined in chapter 1, section II and illustrated in figures 9 and 10. Bombs are marked to indicate type, weight, model, filler, lot number, and loading plant and date loaded. In addition, the AIC symbol is stenciled on uncrated bombs.

111. CLASSIFICATION. Because of the many uses for bombs dropped from aircraft, there are many types and sizes of bombs, ranging in weight from 2 to 4,000 pounds. In common with other types of ammunition, bombs are classified according to filler as explosive, chemical, incendiary, pyrotechnic, and inert. Explosive bombs are classified according to use as general-purpose (GP) (demolition), light case (LC), armor-piercing (AP), semi-armor-piercing (SAP), fragmentation, and depth. Chemical bombs are classified according to type of filler as gas or smoke. Inert bombs are used for practice and drill.

112. EXPLOSIVE BOMBS.

a. These bombs are intended for the destruction or demolition of materiel targets. The destructive effect is produced by the violence of the detonation, "blast effect"; by projection of pieces of the case, "fragmentation"; and by displacement of earth and buildings, "mining." An explosive train for bombs is illustrated in figure 83.

b. **General-purpose.** The general-purpose (GP) bomb (fig. 84) meets the requirements of most bombing missions. The various models range in weight from 100 to 2,000 pounds and the quantity of explosive in this type averages 55 percent by weight. General-purpose bombs may be used for blast, fragmentation, or mining effect. They use both nose and tail fuzes. Nose fuzes produce more efficient surface effect, and tail fuzes produce more efficient mining and penetration effect. Both fuzes are generally used, the secondary fuze as insurance against malfunctioning. The metal case is strong enough to withstand impact with ordinary materials when released from high altitude, but it may fail on impact with heavy armor or heavily reinforced concrete structures.



RA PD 104840

Figure 121 — Packing Box for Aircraft Parachute Flare

b. Trip flares are primarily used to give warning of enemy marauders or infiltrating hostile troops. Secondary use of the trip flare is for illumination of such troops or for signaling. They are similar to booby traps in that they are left in the path of an advancing enemy and depend upon some action of the enemy for initiation. One model resembles a bounding antipersonnel mine (fig. 116), since it propels a shell containing a parachute-supported candle into the air 300 to 500 feet high where the candle is ignited and expelled from the shell case. Another resembles a hand grenade in size and shape (fig. 117) with the addition of a bracket for attachment to a tree or post and a trigger mechanism for firing. Unlike hand grenades, the fuze has no delay element.

131. ILLUMINATING SHELLS. These pyrotechnic items are provided for illumination by ground troops of objectives beyond the range of other flares. They are fired from mortars or artillery cannon and contain a flare candle, parachute and time fuze. (See chapter 2, sections III and IV.)

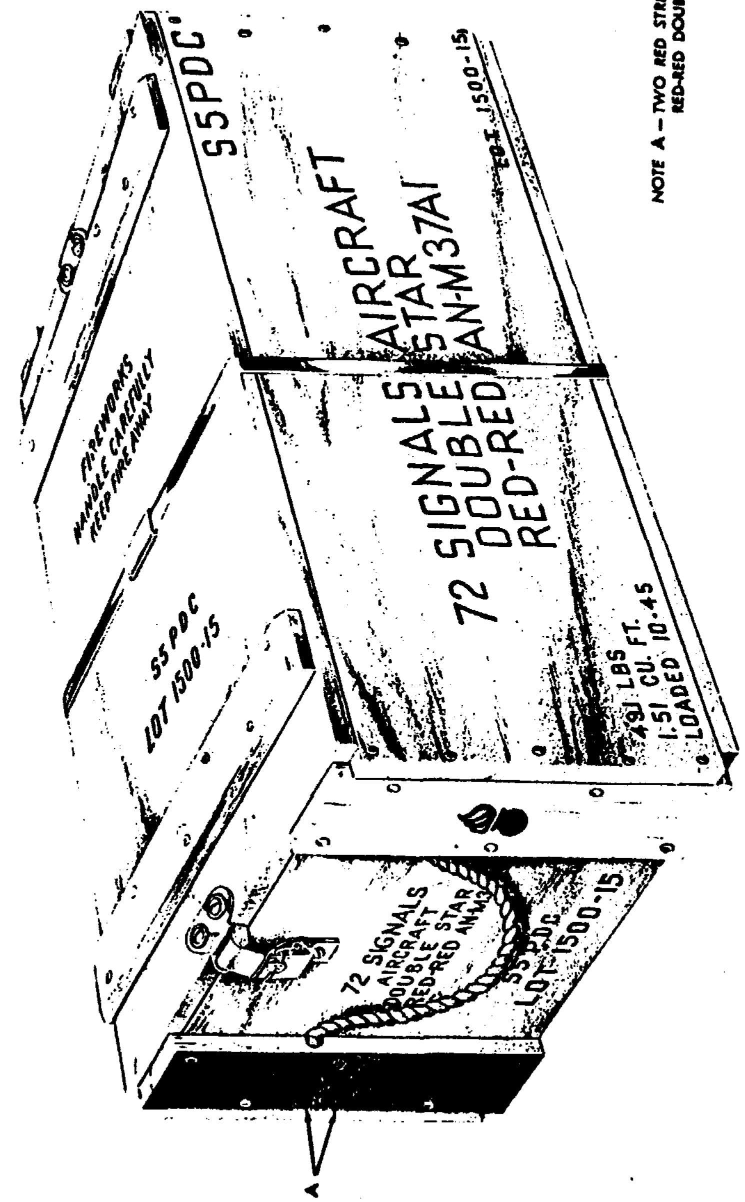
132. GROUND SIGNALS.

a. Standard ground signals (fig. 118) are launched by means of grenade launchers M1, M7, and M8 attached to caliber .30 rifles or carbines. These signals consist of the signal assembly and the stabilizer fin assembly. The signals may be green, amber, red, or white in color and may be of the parachute type or five-star cluster type. A new series of ground signals produces red, orange, green, violet, or yellow smoke.

b. The high-burst-ranging signal M27 (fig. 119) is fired from the ground signal launcher M1A1; the high-burst-ranging signal M27A1B1 (fig. 119) is fired from standard grenade launchers similar to standard ground signals. This signal simulates the high burst of artillery shell for ranging practice. It rises to an altitude of approximately 550 feet when fired from the ground launcher M1A1 and approximately 700 feet when fired from the grenade launcher. The burst is accompanied by a flash, a puff of gray smoke, and a noise which can be heard for a distance of at least 2,000 yards.

133. DISTRESS SIGNAL. This signal is for use at sea. It is assembled in an all metal body and is not adversely affected by prolonged exposure to water vapor. The distress signal M75 has a self-contained projector and the signals M13 are for use with the pyrotechnic projector M10.

134. FLASH AND SOUND SIGNAL. The flash and sound signal M74 is intended primarily for control umpires to simulate air burst of artillery fire for training troops. It is fired from the pyrotechnic



NOTE A — TWO RED STRIPES TO INDICATE RED-RED DOUBLE STAR SIGNAL

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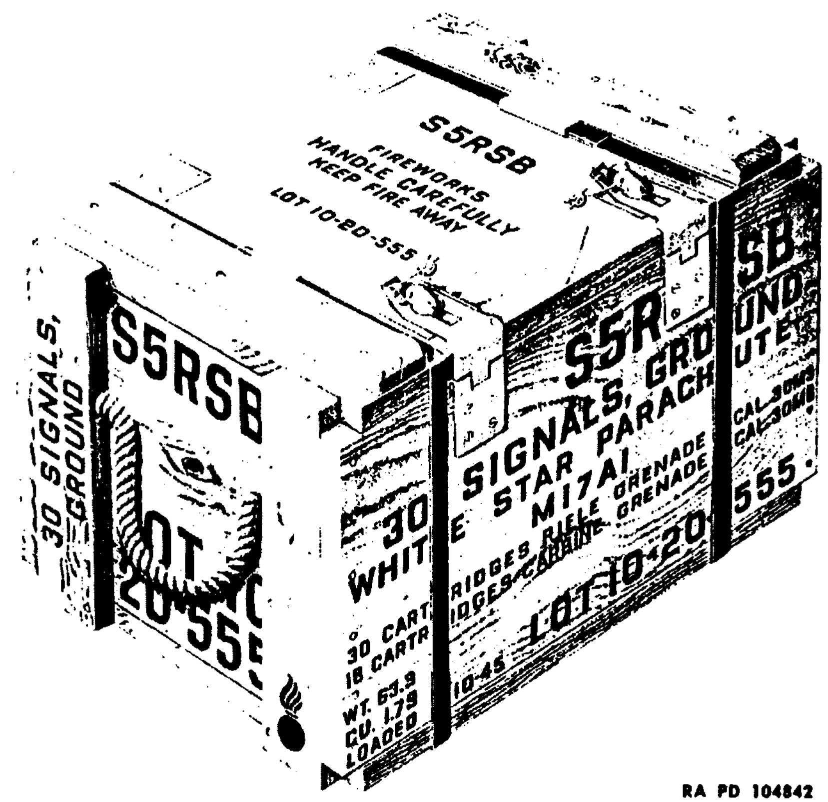
Figure 122 — Packing Box for Aircraft Signals



RA PD 104842

Figure 123 — Packing Box for Ground Signals

pistol M8 or the hand pyrotechnic projector M9. In appearance it is similar to the cartridge type aircraft signals. At an elevation of 45 degrees, the height of burst of the signal is about 100 feet.

135. RED FUSEE. The 20-minute red fusee M72 is similar to commercial type fusees. It consists of a cylindrical paper tube filled with red flare composition and a sharp nail protruding through the wooden bottom plug. A match head imbedded in the top of the flare composition may be ignited with a striking composition block.

136. IDENTIFICATION. In addition to the standard markings and painting (chap. 1, sec. II), varieties of one type of signal carry, as a means of identification among themselves, markings as follows:

a. Aircraft signals are distinguished by the color and embossing on the identification top (outer wad), and by bands in the color of the signal produced.

b. Some ground signals are distinguished by the color and embossing on the fin, others by the color and embossing on the identification top.

c. For information of those installing flares M8A1 and M24 in aircraft, the word "FRONT" is stenciled on the front of the case and the location of suspension bands is indicated by black bands painted on the case.

d. Over-age and substitute composition flares assigned to training will have a blue band approximately 2 inches wide painted around the body immediately below the label. These flares may also be stenciled "FOR TRAINING USE ONLY".

137. CARE, HANDLING, AND PRESERVATION. Pyrotechnics contain material of an intrinsically hazardous nature. In general, the same regulations apply to pyrotechnics as for other types of ammunition, covered in chapter 3, sections I and II. In addition, the following will be observed:

a. Pyrotechnics are protected from moisture by moistureproof hermetically sealed containers. When containers show signs of dampness or moisture, they will be opened and if there is evidence of moisture on the pyrotechnics, they will be destroyed by authorized and experienced personnel. As pyrotechnics are very hygroscopic, they should not be removed from standard packings any sooner than necessary prior to use.

b. Besides the hazardous pyrotechnic compositions, pyrotechnics contain sensitive elements, such as fuzes, friction compositions, and primers. Disassembly of pyrotechnics or components is prohibited. Boxes containing signals which are discharged by percussion primers should be placed flat with the top of the box up. Protective or safety devices should not be removed until just before use. Care should be taken to avoid damage to fiber cases and parachute pull-out cords. Pyrotechnics, especially projected types which are seriously dented or deformed will not be used, as a damaged barrel or case might cause a round to become lodged in the bore of the projector. It should be kept in mind that photoflash powder is as hazardous as black powder.

c. Storage of pyrotechnics is described in chapter 3.

d. The incendiary effect of pyrotechnic material should be kept in mind in using such material in the vicinity of dry brush and grass.

e. Pyrotechnic material is poisonous to men and animals if taken internally.

f. During maneuvers over terrain, other than military reservations, the location of dud flares and photoflash bombs will be observed and reported. The duds will be sought out and destroyed, as soon as possible, as instructed in chapter 4.

138. PACKING. Due consideration is given in packing of pyrotechnics to prevent contact with moisture. Pyrotechnics are packed in metal-lined or unlined, nailed or wirebound wooden boxes. Those in unlined boxes are placed in inner containers consisting of sealed corrugated board cartons, cylindrical fiber containers, or metal containers. The cartons are dipped in paraffin to protect the contents from moisture. See figures 120, 121, 122, and 123.

Section VII

ROCKETS

139. GENERAL. A rocket is a projectile which is propelled by the reaction, or recoil, from discharging a jet of gas to the rear at high velocity. The gas is produced by the burning of a propelling charge within the rocket itself. A military rocket consists of a head, or shell, and a motor. The head contains the explosive or chemical charge and a fuze; it is similar in function to an artillery shell or a bomb. The motor consists of a tube closed at one end and constricted near the other to form a nozzle; it contains the propelling charge and an igniter. Fins may be attached to the motor to stabilize the rocket in flight. The principal advantages of rocket ammunition are that it imparts little or no recoil to the weapon and does not require a rifled barrel. A further advantage lies in that the forces of setback are spread over a long period of acceleration rather than concentrated in a short time as in a gun. Consequently rocket propulsion can be used for light case missiles of high capacity with fuzes of more fragile construction. The disadvantages are, that protection is required against the blast of hot gas from the tail of the rocket, and that rocket dispersion is greater than that of shell of similar caliber. The weapon used in firing the rocket is designated a launcher since it serves only to give the rocket its initial direction and does not project the rocket as a gun or mortar.

140. CLASSIFICATION.

a. Rockets are classified according to the filler of the rocket head as explosive, chemical, practice, or target (figs. 16 and 124 through 131).

b. **Explosive rockets.** Explosive rockets contain a high-explosive filler and are further classified as:

(1) HIGH-EXPLOSIVE (HE), which has a relatively large charge of explosive for blast, fragmentation, or mining effect at the target.

(2) HIGH-EXPLOSIVE, ANTITANK (HE,AT), which contains a special shaped explosive charge particularly effective against armor.

(3) DEMOLITION, which has an exceptionally thin case and a correspondingly large charge of high explosive.

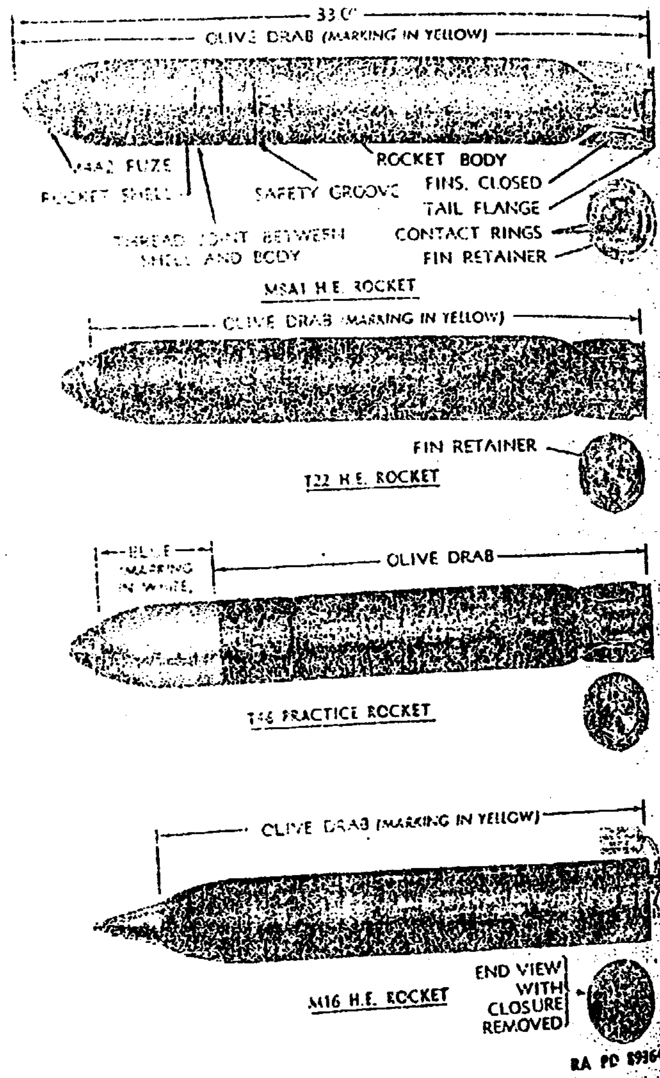


Figure 127 — 4.5-inch Rockets

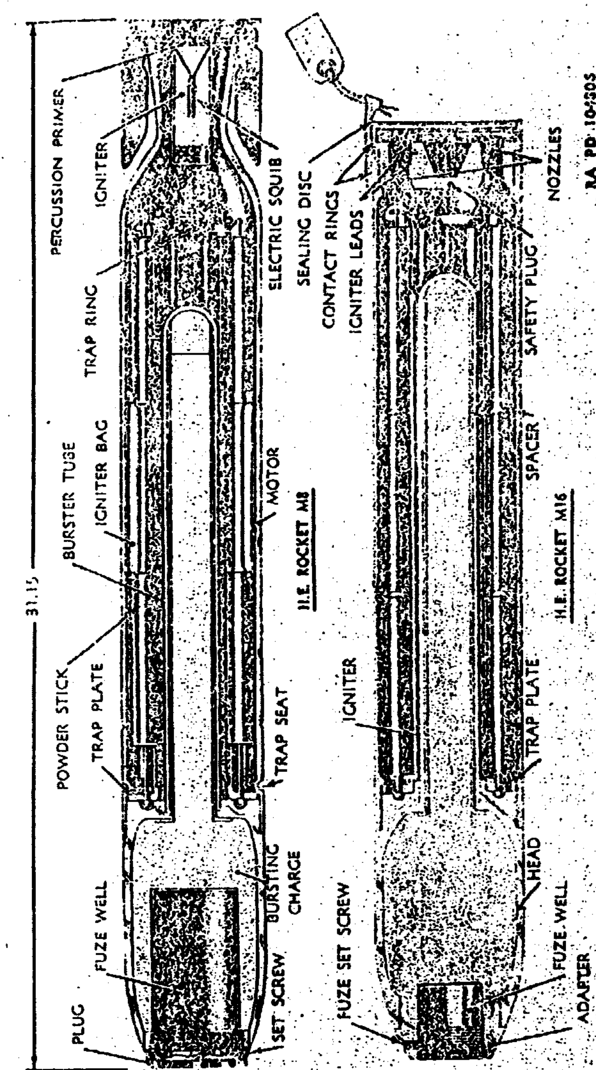


Figure 128 — 4.5-inch Rockets — Cross Section

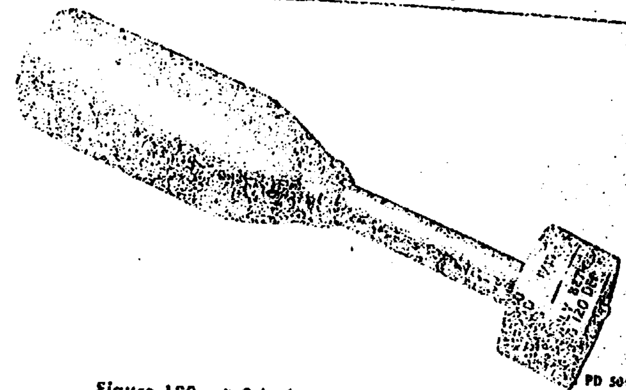


Figure 129 – 7.2-inch HE Rocket T37 – Assembled

d. **Practice rockets.** Practice rocket shells are loaded with inert material to the weight of the corresponding service rocket. The fuze may be inert or may contain a spotting charge. The motor for the practice rocket is the same as that of the corresponding service round.

e. **Target rockets.** Target rockets are supplied to furnish fast moving flying targets for automatic AA gun practice.

141. IDENTIFICATION. Rockets, in common with other types of ammunition, are identified by the standard nomenclature and lot number of the item. Such identification is marked on all containers and, unless the item is too small, on the ammunition itself. The basic color scheme for painting and marking on the ammunition is given in chapter 1, section II and illustrated in figure 16.

142. COMPONENTS.

a. For flexibility of supply, a complete round, as issued, may contain alternative components, only one of which may be used. The complete round may be issued as a single assembled item or as separate components to be assembled in the field.

b. **Head.** The head of the rocket consists of the loaded rocket shell, and the fuze. It is usually assembled to the forward end of the motor, but in some models, the shell may extend into the motor to use the motor tube as an additional source of fragments. It carries the explosive or chemical charge to the target. It may have thin walls to increase its capacity of explosive for blast effect, it may have thick walls to penetrate armor before exploding or it may have walls of medium thickness to provide a maximum number of effective fragments. A fuze is attached to the motor to function it at the time and under the circumstances desired.

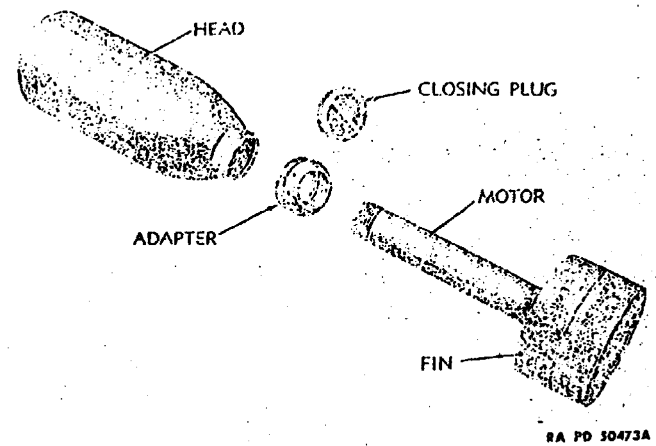


Figure 130 – 7.2-inch HE Rocket T37 – Components

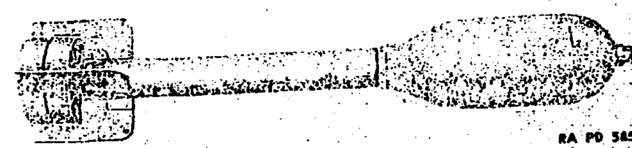


Figure 131 – 7.2-inch Chemical Rocket T21

c. **Motor.**

(1) GENERAL. The rocket motor is assembled to the rear of the head. It consists of a hollow tube which is closed at the forward end and has a nozzle in the form of a venturi tube at the rear. The motor contains the propelling charge and the igniter. Fins for stabilizing the flight of the rocket are attached to the outside of the motor at the rear end, except on spin-stabilized rockets. Spin-stabilized rockets have several venturi tubes concentrically located about and all inclined to the longitudinal axis of the rocket in the same direction so as to produce spin when the gases are emitted through them.

(2) IGNITER. The igniter consists of a primer and a charge of black powder assembled within the motor. The primer is fired by the heat generated in a wire by electric current. The primer ignites the black powder which in turn ignites the propelling charge.

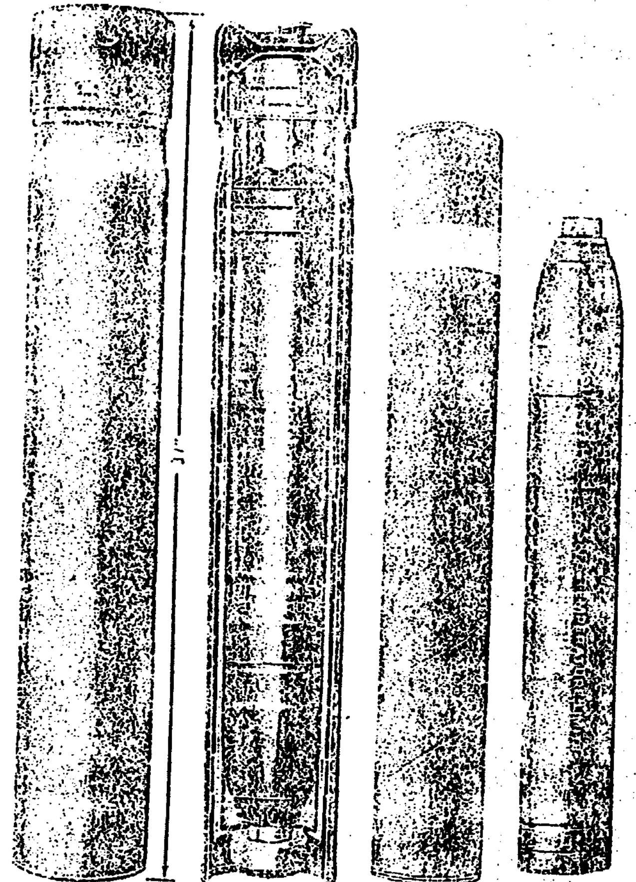


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Figure 132—Metal Can Packing for Rocket

(3) PROPELLING CHARGE. The propelling charge consists of double-base powder in the form of sticks which may be solid or may have an axial perforation. The size of the propelling charge is usually indicated by the total length of powder sticks plus the web diameter of the grain. This makes for uniformity of burning and controls the burning rate. When the propelling charge is ignited it burns and produces gases under high pressure within the motor. The gases escape through the nozzle producing the jet which drives the rocket. The propelling charge is held in place in the motor by a trap assembly. The trap may be in the form of a grating or may be in the form of a cage with the perforated sticks threaded on the bars.

(4) EFFECT OF TEMPERATURE. The burning rate of propellent powder varies with the temperature and the pressure. That is, the higher the temperature or pressure, the faster the powder burns. When rockets are fired at temperatures higher than those for which they are designed, the propelling charge builds up pressure faster than the nozzle can release it and, as a consequence, dangerous pressures are built up which may cause the motor tube to burst. When rockets are fired at temperatures below the specified range, the charge burns slowly and produces erratic ranges. It may also cause undesirable back blast after the rocket leaves the launcher.

143. LAUNCHERS.

a. **Characteristics.** To meet the characteristics required of a weapon for firing the rocket, the launcher has only to provide means of aiming, firing, and blast protection.

b. **Aiming.** This requirement is met if the rocket is pointed in the proper direction at the moment of firing. A light metal or plastic tube, a pair of parallel rails or an improvised trough may serve to give the rocket its initial direction. Such devices may be carried by personnel or mounted on a light carriage.

c. **Firing.** In general, rockets are fired by a pair of electrical contacts connecting the igniter with a battery or generator.

d. **Blast protection.** Minor caliber rockets have a short burning time and generally burn out before leaving the launcher. A small conical blast deflector is sufficient to protect the firer against the occasional long-burning round. In medium and major caliber rockets, the propelling charge continues to burn for 30 to 100 feet beyond the launcher, and blast protection is provided in some cases by metal shields on the carriage and in others by providing lead wires long enough to permit firing the rocket from a safe distance to the side.

e. **Multiple launchers.** A number of tubes or sets of rails may be assembled as a unit and mounted on one carriage. The firing mechanism of such a mount permits firing individually or in salvo.

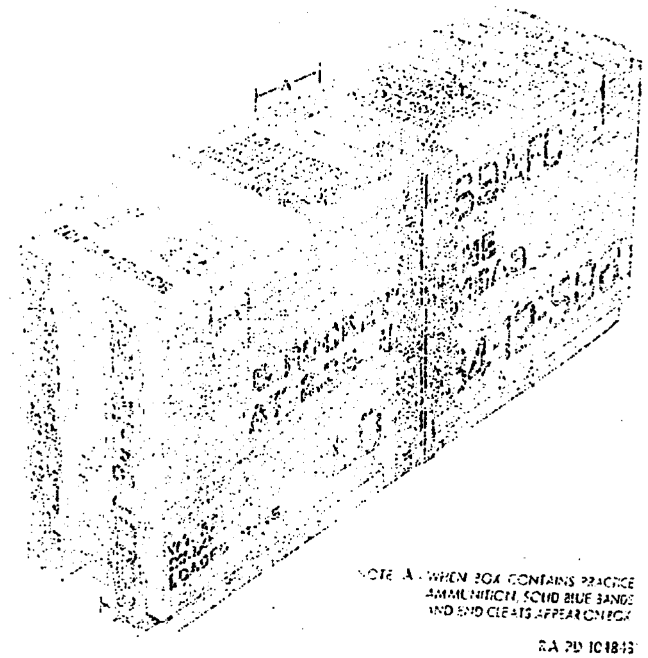

Figure 133 — Packing Box for 2.36-inch HE, AT, and Practice Rockets

144. PRECAUTIONS.

a. In addition to the general precautions in chapter 3, the precautions in the following paragraphs will be observed.

b. Rockets should be protected against sources of high temperature such as exposure to the direct rays of the sun. Those rockets which are known to have been exposed to higher temperatures than the limits indicated on the packing will not be used. They will be placed in segregated storage until they can be destroyed.

c. When rockets are involved in a fire, their range is not limited compared to service ranges, as is the case with other types of ammunition. This fact should be kept in mind in storing rockets. They should, if practicable, be kept in barricaded storage.

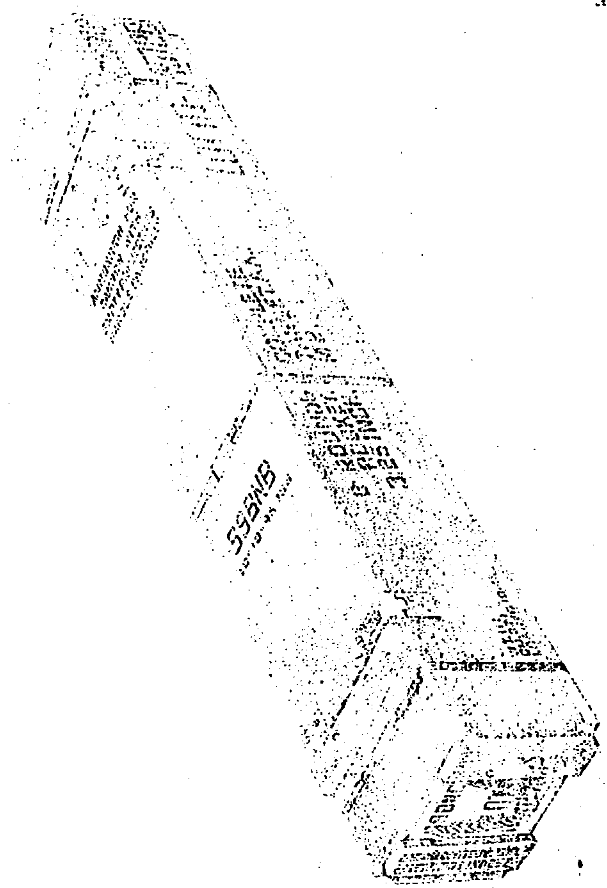

Figure 134 — Packing Box for 3.25-inch AA Target Rocket [illegible]

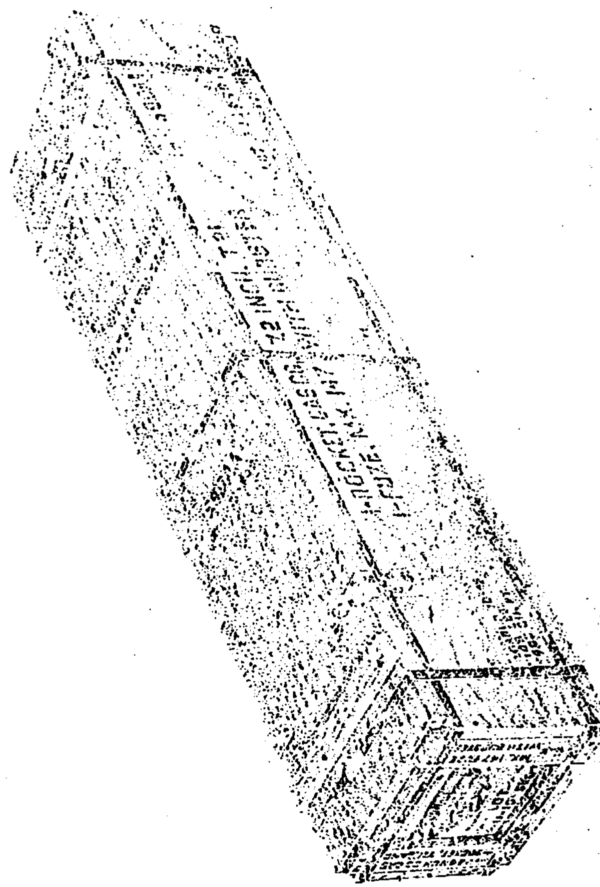

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Figure 135.— Packing Box for 7.2-inch CG Gas Rocket T21

d. Chemical rockets stored for one year will be inspected 100% for corrosion and leakage.

e. If any change is made in an item, such as altering the propelling charge for a different temperature range, the item will be marked to indicate the change. If the item is repacked, the packings will be marked likewise.

f. Care should be exercised to avoid denting motor tubes and bending the fins. Rockets with seriously dented tubes will not be fired because such denting increases the loading density which may cause dangerous pressures on firing. Damaged fins will cause erratic flight.

g. Rockets should not be fired at temperatures outside the limits specified.

h. Care should be exercised in firing through a screen of brush or trees. Impact with a twig or branch may deflect the rocket or cause it to detonate.

i. In making connections for electrically fired rockets, care should be exercised to insure that all connections are good and that uninsulated sections of the firing circuit are protected against short circuit.

j. The blast area to the rear is specified for each type of rocket. Personnel and materiel must not be permitted in this area after a launcher is prepared for firing until the rocket has been fired or the launcher unloaded. If practicable, combustible material should be removed from this area.

k. Ammunition, including rockets for immediate use, will not be stored within 100 yards behind the firing point. Nor will any ammunition be permitted within 10 yards to the side of the firing point unless it has the same protection from blast as is specified for personnel.

145. PACKING AND SHIPPING. Small rockets are packed as assembled complete rounds in cylindrical sealed fiber containers which in turn are packed in a wooden box. Medium caliber rockets are packed, unfuzed, in sealed fiber containers which are packed in clover leaf bundles or wooden boxes. Large caliber rocket heads and motors are packed separately. Point fuzes are packed in sealed individual containers which, in turn, are packed in wooden boxes. Base fuzes are assembled to the rocket shell, as issued. See figures 132 through 135 and ORD 11 SNL S-9.

146. SUBCALIBER ROCKETS. As is the case with subcaliber rounds for artillery weapons, subcaliber rockets are used for large caliber rocket launchers.

Section VIII

LAND MINES

147. GENERAL. All types of land mines consist of a high-explosive charge which is detonated by a mechanical or chemical device (known as the fuze) when actuated by vehicle or personnel. An explosive-containing adapter, known as an activator, is used with some mines so that standard Engineer Corps firing devices may be installed for secondary initiation, such as antilifting devices.

148. CLASSIFICATION. Land mines are classified according to use as antitank or antipersonnel and also, as service, practice, or dummy.

149. METALLIC ANTITANK MINES.

a. *Purpose.* Antitank mines are intended to immobilize and destroy tracked or wheeled vehicles. Details of construction and performance of individual mines are covered in TM 9-1940 and performance and methods of handling are covered in FM 5-31, Land Mines and Booby Traps.

b. **Antitank mines—older models.** The antitank mines M1A1 and M4 are cylindrical steel cases, approximately 3½ inches high and 3¼ inches in diameter, filled with about 5½ pounds of high explosive. A fuze, issued separate from the mine body, is inserted in the fuze well and held in place by a spider. Pressure of approximately 500 pounds upon the spider by a vehicle will cause functioning of the fuze which detonates the explosive charge of the mine. A safety fork assembled between the striker head of the fuze and the fuze body prevents accidental initiation of the fuze during handling. This safety fork must be removed to arm the fuze. The complete round, mine and fuze, weighs approximately 10½ pounds.

c. **Light antitank mine.** A lightweight, flat, quart-sized mine (fig. 136) filled with about 3 pounds of high explosive, usually tetrytol, is intended for antitank use but it may easily be converted for antipersonnel use. It can be detonated by a force of approximately 190 pounds on the pressure plate. A "U" shaped pressure plate fits over the top of the mine and covers the fuze. A flexible wire rope screwed in one end of the mine serves as a carrying strap. Upon removal of the strap, the threaded well may be used for the insertion of a secondary fuze. The mine is rectangular in shape, approximately 7 inches long by 4½ inches wide by 2½ inches high and weighs about 4 pounds. A number of firing devices may be used to guard against tampering with, or removal of, this mine. The same chemical fuze used in the heavy antitank mine is also used in this mine.

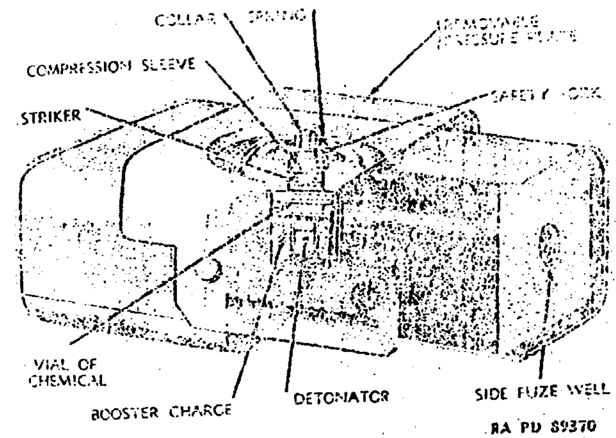


Figure 136 – Light Antitank Mine M7

d. **Heavy antitank mine.** The heavy antitank mine is a high-explosive type intended primarily for use against tanks (figs. 137 and 138). It has a base diameter of 13 inches and a maximum height of 3¼ inches and is loaded with approximately 12 pounds of TNT. This mine resembles the German Tellermine in appearance. The complete assembly weighs approximately 20 pounds. The carrying handle is attached to the bottom of the mine. Permanently assembled to the mine body is a round pressure plate 7½ inches in diameter containing a reversible plug which covers the fuze well. The pressure plate is supported internally by circular (Belleville) springs. The chemical fuze used in this mine is also used in the light antitank mine. A force of approximately 300 pounds on the pressure plate is required to cause the fuze to function. This mine is not affected by stones, dirt, or moisture.

150. NONMETALLIC ANTITANK MINES.

a. **Purpose.** This type mine was developed as a counter measure against metallic mine detectors.

b. **Nonmetallic antitank mine.** This mine consists of nonmetallic components both in body and fuze. It is approximately 5¼ inches high and 10 inches in diameter (fig. 139). Approximate weight of complete assembly is 15 pounds. This mine is provided with a chemical-type fuze. An activation well is provided in the base of the mine so that firing devices may be inserted, including an anti-

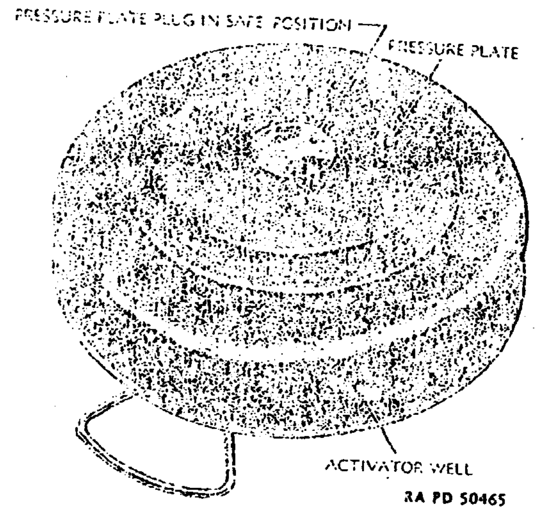


Figure 137 — Heavy Antitank Mine M6

lifting device for exploding the mine upon pick-up. There is no spider on the nonmetallic mine as pressure on any part of the top of the mine body will cause the fuze to function. A force of approximately 300 pounds on the pressure plate is required to cause the fuze to function.

151. ANTITANK PRACTICE MINES.

a. Metallic antitank practice mine. The practice metallic mine M1 has a base diameter of approximately 8¾ inches and a maximum height of 4¼ inches. It is similar to the high-explosive mine but upon activation releases only a puff of white smoke. Some lots of this mine have the filling plug in the top of the mine. The complete round consists of three components; an empty mine body (which has five 1-inch holes equally spaced around the side), the spider, and the fuze. Practice fuzes have the striker head painted red. The mine has the same weight and functions in the same manner as the high-explosive mine and is used for training. It is cheap to manufacture and is not dangerous. The M1B1 is a practice metallic mine and resembles the service mine except that the filling hole is in the bottom of the mine body and that all parts are manufactured by stamping. It is approximately 8¼ inches in diameter and 3½ inches high. This mine is sand-filled to weight before it is issued for use in practice.

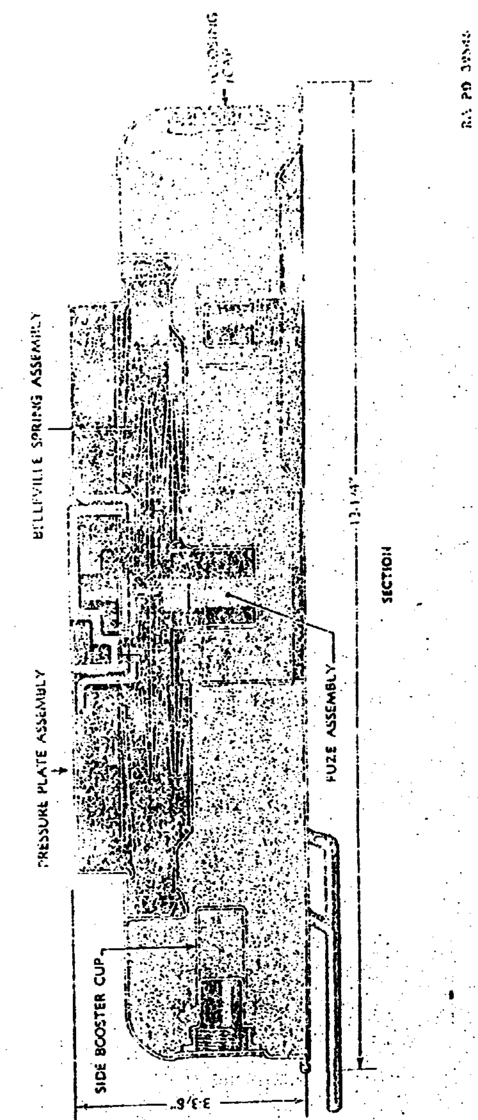


Figure 138 — Heavy Antitank Mine M6 — Cross Section

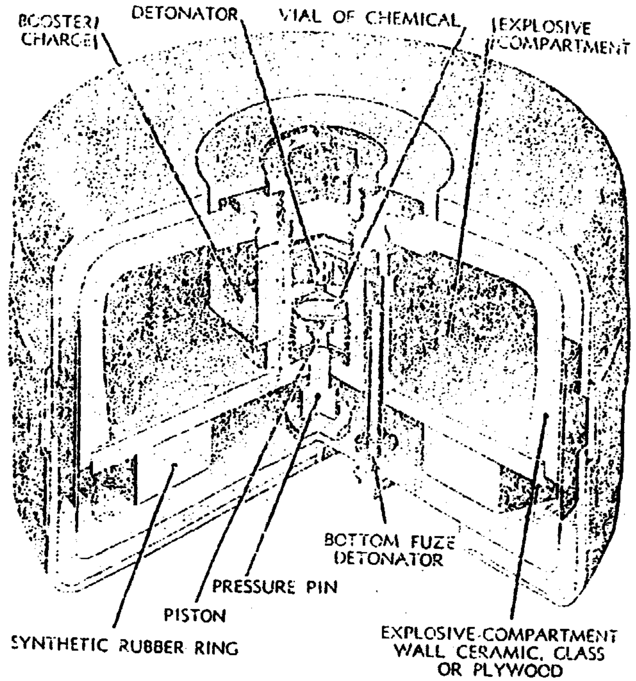


Figure 139 – Nonmetallic Antitank Mine M5

b. Nonmetallic antitank practice mine. The practice nonmetallic mine is identical with the nonmetallic service mine except that it is filled with inert material instead of high explosive and is marked in white. This practice mine has the same weight and functions in the same manner as the service mine. The practice fuze resembles the service fuze in external appearance, except for the marking. After the fuze is initiated there is a delay of 2 to 3 seconds. Then a cloud of smoke is produced and a charge is projected several feet into the air where it explodes with a flash and a loud report.

152. PACKING AND MARKING OF ANTITANK MINES.

a. Metallic mines M1A1 and M4 are packed in wooden boxes, each of which contains five mines and five fuzes. The box is made

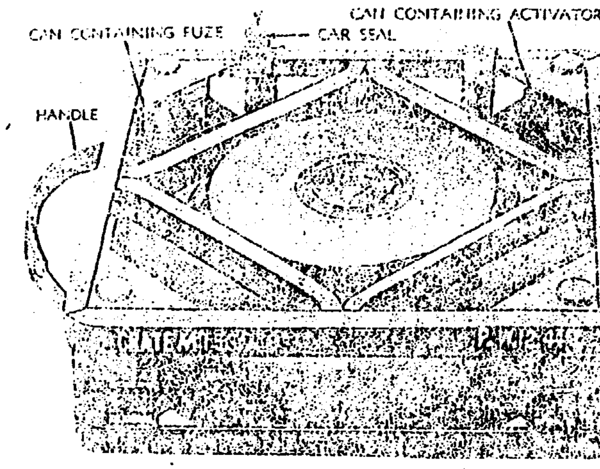


Figure 140 -- Metal Crate M153, Containing One Heavy Antitank Mine M6, With Fuze and Activator

up with a set of plywood separators. As shipped, the fuzes are placed in a compartment, which occupies one section at the end of the box; the five mines, with spiders nested to the bottoms of the mines, are packed in the other five compartments. Total weight of box including mines and fuzes is 70½ pounds. The nonmetallic mines are packed in the same manner, but with four mines and four fuzes in a box. Each fuze is packed in a hermetically sealed container, the fuzes being placed in a section in the center of the box. Total weight of box including mines and fuzes is approximately 88¼ pounds. The heavy mine is packed individually in a metal crate (fig. 140), the fuze and the activator, each in a hermetically sealed can, being placed in corners of the crate. Some mines are packed without the activator. Total weight is 30½ pounds. The light mine is packed in a metal box containing eight mines, eight fuzes, eight carrying handles, and eight cloth bags. Total weight is 56 pounds. In this metal box, there are six compartments, the two outer compartments holding four fuzes each, each fuze in a sealed container with four of the fuzes in a carton. Each of the four central compartments contains two mines. The carrying handles and cloth bags are laid on top of the contents of the box.

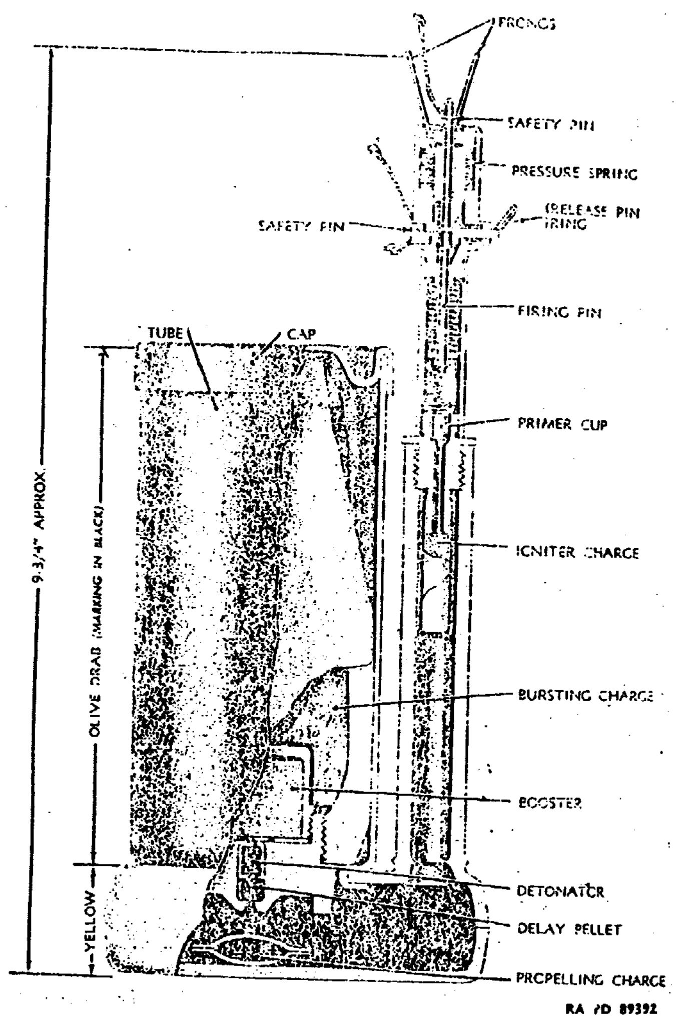


Figure 141 — Antipersonnel Mine M2A4, With M6A1 Fuze

b. The boxes containing practice mines are painted with a blue band around the center of each box and blue cleats on the ends of each box. Wooden boxes of high-explosive mines are stained light brown with marking in yellow, or, more recently, unstained with marking in black. Metal boxes are painted olive drab.

153. ANTIPERSONNEL MINES.

a. **Purpose.** Issued antipersonnel mines are standardized mechanisms intended for effect against personnel.

b. **"Bounding" antipersonnel mine.** This mine, when functioned, throws a projectile upward to a height of 4 to 6 feet. It has an effective radius of about 30 feet. The complete assembly weighs approximately 5 pounds. The mine has the appearance of a small mortar with an attached firing device (fig. 141). The projectile is thrown into the air by the burning of small propelling charge of black powder in the base of the mine. The mine is painted olive drab on which the markings are in black; the base is painted yellow.

c. **Cast-iron fragmentation mine.** This type of antipersonnel mine resembles a brick (fig. 142). It is approximately 5½ inches high and 3½ inches square. There are three threaded wells in the mine body, one in each of two sides and one in the end, to accommodate standard Corps of Engineers firing devices (fuzes). A relatively heavy charge of TNT and thick walls produce fragmentation and blast effect. When used above the ground, the bursting radius of this mine is greater than that of the bounding type mine. It is painted olive drab with markings in black.

d. **Practice antipersonnel mine.** The practice antipersonnel mine (fig. 143) simulates the "bounding" type antipersonnel mine. The metal parts are the same as those used for the service mine, except for the projectile which is made of cardboard and the igniter which contains a delay element to provide for a delayed functioning of the mine four seconds after functioning of the fuze. The projectile contains a spotting charge assembly which resembles a shotgun shell with a delay element in place of the primer. In order that the mine may be used several times, the following replacement parts are issued:

- Primer and igniter assembly.
- Cap (cover).
- Projectile.
- Spotting charge.
- Propelling charge.

e. **Packing and marking.** The "bounding" antipersonnel mine is packed complete with a firing device and a spool of steel wire in a corrugated paper jacket. Ten such containers are packed into a

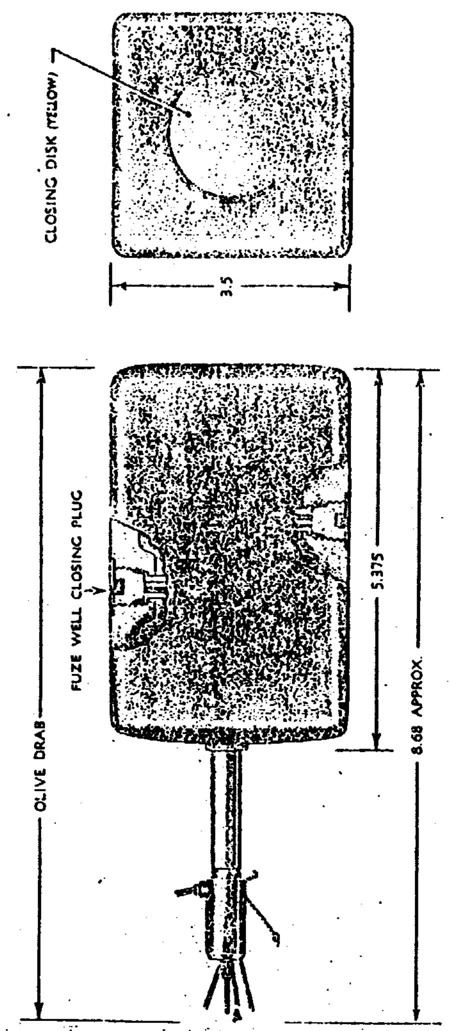


Figure 142 — Antipersonnel Mine M3, With M7A1 Fuze

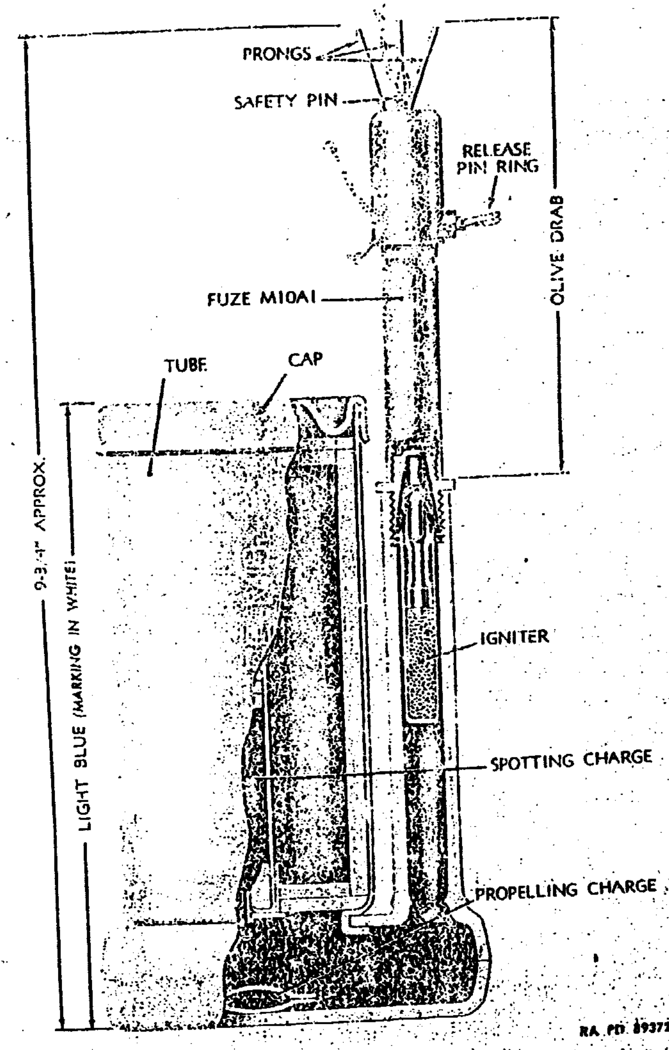


Figure 143 — Practice Antipersonnel Mine M8, With M10A1 Fuze

wooden box, which is stained light brown with marking in yellow, or, more recently, unstained with marking in black. The cast-iron fragmentation antipersonnel mine is packed in a wooden box containing 6 mines, 6 fuzes in individual containers, and 6 spools of wire. The practice antipersonnel mine is packed 2 mine bodies and 2 fuzes, with 20 sets of replacement parts, per wooden box. The box has markings in black, a blue center band and blue vertical end cleats.

Section IX

DEMOLITION MATERIALS

154. GENERAL. Demolition materials include explosive equipment intended for destruction of obstacles (by bangalore torpedoes), fortifications (by shaped charges), special equipment (by destructors), and general material (by demolition blocks). Most demolition charges may be fired electrically by electric blasting caps or nonelectrically with safety fuse and nonelectric blasting cap or delay detonators. For detailed information, see FM 5-25 and TM 9-1940.

155. BANGALORE TORPEDOES. The bangalore torpedo M1A1 (fig. 144) is a tube or pipe filled with high explosive. The steel tube or pipe is 5 feet in length and 2⅛ inches in diameter, and is grooved and capped at each end. The tube is filled with amatol, with about 4 inches of TNT at each end. The weight of the explosive charge is about 9 pounds. The torpedo may be used as an explosive charge for other demolition purposes. The bangalore torpedo M1A1 is packed 10 per kit or box which also contains 10 connecting sleeves and 1 nose sleeve.

156. DESTRUCTORS.

a. General.

(1) Destructors are high-explosive charges fired electrically or by the action of a fuze.

(2) Destructors are for use in certain equipment to be destroyed when the materiel is abandoned or when there is danger of its falling into enemy hands. In general destructors are intended for destruction of the vital parts of the materiel by means of an explosion which is confined within the housing. Destructors may be removed from material during normal maintenance repair.

b. Destructor AN-M1. This destructor (fig. 145) is a small explosive container which fits a threaded adapter in certain radio equipment. The head end has a screwdriver slot and is threaded for screwing into the adapter. At the opposite end is a gilding-metal case which is separated from the head end by a plastic tube. The head end contains a small cylinder of nitrocellulose and the ignition wire. The

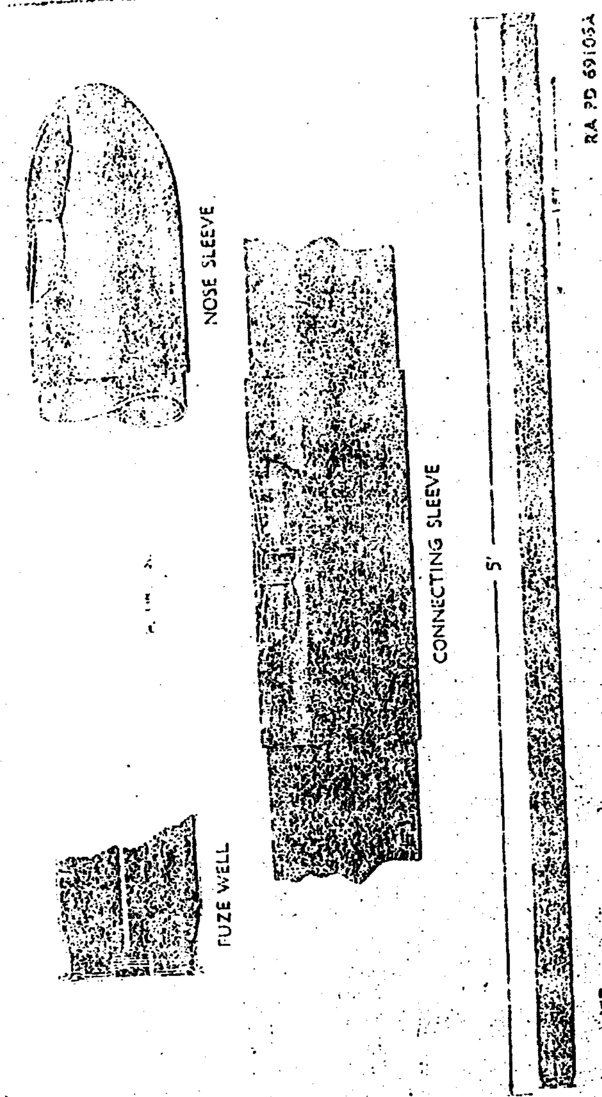


Figure 144 — Bangalore Torpedo M1A1

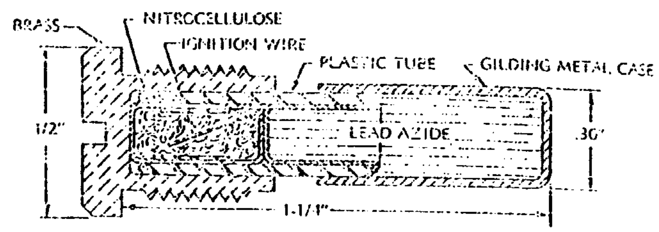


Figure 145 – Destructor AN-M1 – Sectioned

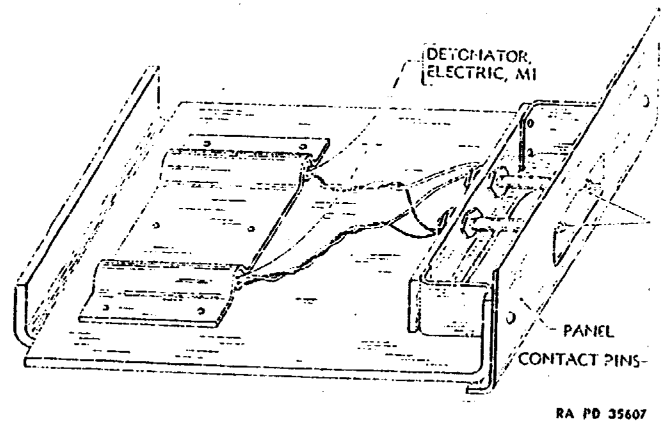


Figure 146 – Destructor AN-M2

metal components at each end of the unit are insulated from each other. When the electrical circuit is closed, the current passes through the ignition wire which, in turn, detonates the destructor.

c. **Destructor AN-M2.** This destructor (fig. 146) consists of a simple sheet-metal platform, upon which the various electrical and explosive components are secured. The rear and forward edges of the platform are curved upward and a panel is attached to the forward edge. The whole assembly is 1½ inches high. This destructor fits into an opening in the enclosing box of certain equipment with which it is used. When a switch is closed, the electric current causes the electric detonators to function.

d. **Destructor AN-M3A1.** This destructor (fig. 147) resembles the destructor AN-M1 in general appearance but is much larger. It

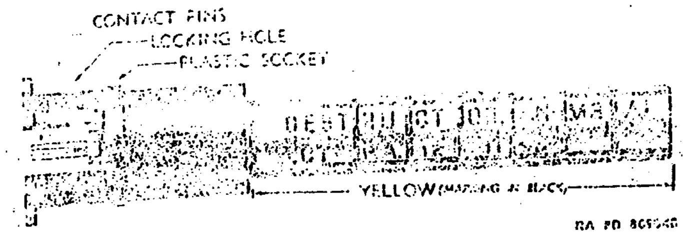


Figure 147 – Destructor AN-M3A1

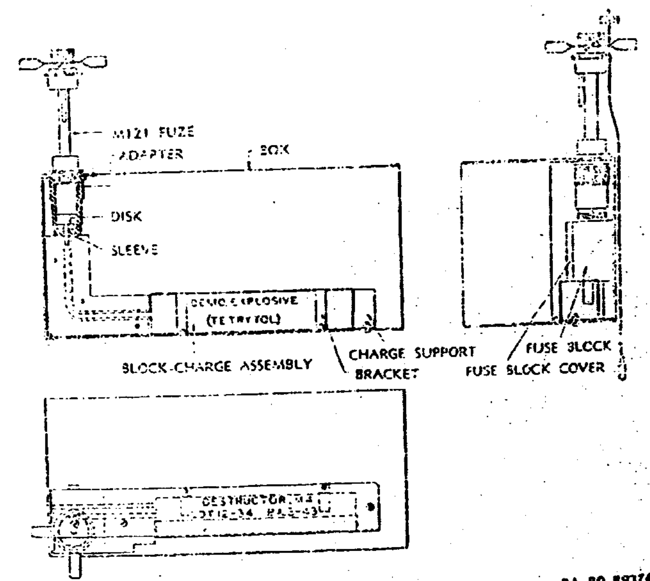


Figure 148 – Destructor M4

contains an electric detonator and a 2-gram pellet of tetryl. When a switch is closed, electric current enters the destructor through the two contact posts attached to lead wires from the plane. The current causes the detonator to explode which, in turn, explodes the tetryl pellet.

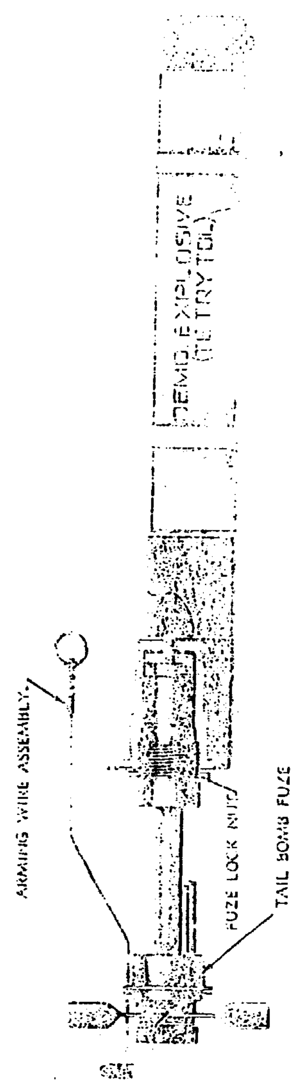


Figure 149 — Destructor M5

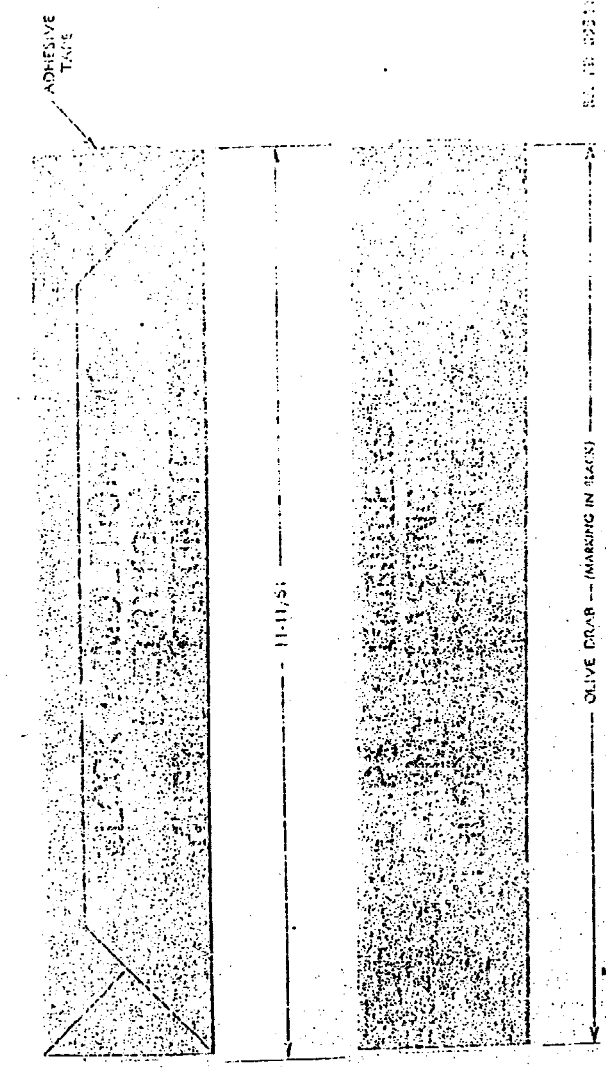


Figure 150 — Demolition block M2

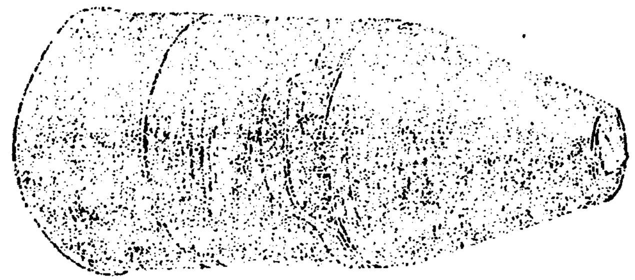


Figure 151 -- Shaped Charge, 15-lb, M2A3

e. **Destructor M4.** This destructor (fig. 148) consists of a 2½-pound block of tetrytol mounted on an L-shaped bracket, an impact-type of bomb tail fuze, and accessories for assembly and mounting in a control unit. The main destructor assembly consists of an adapter, into which the fuze fits, and the explosive block mounted on an L-shaped sheet-metal support.

f. **Destructor M5.** This destructor (fig. 149) is essentially a modification of the destructor M4. The complete assembly weighs approximately 8½ pounds.

157. DEMOLITION EXPLOSIVES.

a. **TNT and nitrostarch.** Compressed TNT in ½- and 1-pound blocks, and nitrostarch in ¼-pound blocks, are supplied for demolition and like purposes. These may be used by themselves (with any standard firing mechanism equipped with a detonator) or in conjunction with other demolition materials. Nitrostarch is more sensitive than TNT; hence, nitrostarch blocks should not be crushed or broken.

b. **Demolition block M2.** This demolition block (fig. 150) is a rectangular block of tetrytol, with a detonator well in each end. At the outer end of each well is an adapter threaded to receive any of the standard firing devices. At the inner end of each well is a tetryl pellet cast in the block to act as a booster. The demolition block is packed in a cardboard box, 8 boxes per haversack, 2 haversacks per box.

c. **Demolition block M3.** This demolition block is a rectangular 2¼-pound block of plastic explosive. The block consists of Composition C-3 and one block is equivalent to six ½-pound TNT blocks. This plastic explosive can be molded by hand into any desired shape or position and is very efficient, due to the good contact thus obtained combined with its high power. The demolition block is packed in a cardboard box, 8 boxes per haversack, 2 haversacks per box.

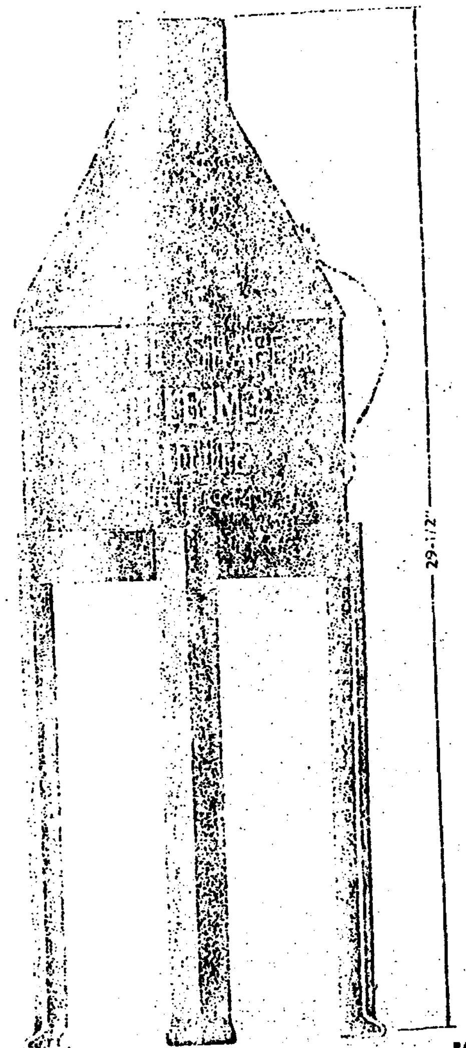


Figure 152 — Shaped Charge, 40-lb, M3

d. Demolition block M4. This demolition block is a ½-pound block of Composition C-3 and has the same plastic qualities as the block M3. The block M4 is packed 104 blocks per box.

158. SHAPED CHARGES.

a. Shaped charges are explosives which are formed into special shapes for the purpose of focusing the detonation into a penetrating jet. Such a charge has much greater penetrating capacity than a regular block charge of the same weight.

b. Shaped charge 15-lb. This charge (fig. 151) contains approximately 12 pounds of 50/50 pentolite in a moisture-resisting molded fiber container. The top of the charge has a threaded cap well for receiving an Engineer's Special (or other standard issue) blasting cap. The container extends beyond the base of the charge to hold the charge at the correct distance (called "stand-off") from the target to obtain maximum penetration. This charge will penetrate 36 inches of reinforced concrete. If the concrete is of greater thickness, it will produce a hole approximately 30 inches deep and 2 to 3 inches in diameter. This charge is packed 3 per wooden box; 4 in a carton, 2 cartons per wooden box; or 4 in a fiber container, 1 container per wooden box.

c. Shaped charge 40-lb. This charge (fig. 152) contains approximately 30 pounds of 50/50 pentolite in a metal container. A threaded cap well is provided for receiving an Engineer's Special (or other standard issue) blasting cap. Metal legs provide the correct stand-off distance which must be maintained for maximum penetration. This charge will penetrate a 60-inch concrete wall. The resulting hole will be large enough to insert a standard bangalore torpedo.

CHAPTER 3

CARE, HANDLING, AND PRESERVATION

Section I

GENERAL SAFETY PRECAUTIONS

159. GENERAL.

a. This section deals with the hazards inherent in the storage, maintenance, handling, and intraplant transportation of ammunition. Where rules are given covering related subjects and operations, they should be considered as general.

b. When work is done which involves the direct exposure of explosives material to possible friction, sparks, impact, static electricity, etc., the regulations contained in the Ordnance Safety Manual should be followed. Example of such work is ammunition destruction. The Safety Manual covers safety in the performance of the operation and in the type of equipment necessary for the performance of it.

160. GENERAL PRECAUTIONS.

a. Investigation of accidents which have occurred in the handling, shipping, and storing of explosives and ammunition indicates that, in most cases where the cause could be determined, the accident was due to circumstances which may be classed as controllable. Therefore, the following general safety precautions will be strictly enforced.

b. For personnel.

(1) Ammunition will be handled under the direct supervision of a competent person who understands thoroughly the hazards and risks involved. Persons handling ammunition will be impressed with the fact that their safety, as well as that of others, depends upon the intelligence and care exercised by themselves and by their fellow workers.

(2) Personnel handling ammunition must not tamper with any components or disassemble any components, unless especially authorized to do so. Serious accidents may result.

(3) Persons handling ammunition will clean all mud and grit from their shoes before entering the magazine, car, boat, or vehicle in which there are explosives or ammunition.

(4) Appropriate protective clothing and safety equipment will be provided and its use required.

(5) Safety shoes will be worn in locations where operations require the handling of exposed explosives which may be ignited by static discharge or where there may be exposed explosives capable of being ignited by friction or impact. Details of types of safety shoes, con-

ditions under which they should be used, and a list of explosives requiring use of such footwear may be obtained from the Office of the Chief of Ordnance.

c. In ammunition handling.

(1) The handling of ammunition should always be conducted so as to limit the number of personnel exposed and the hazardous material handled to as small a quantity as is practicable.

(2) Explosives and ammunition will be handled carefully. Bale hooks will not be used under conditions where the container may be penetrated by the hook or fall off the hook. Containers will not be tumbled, dragged, thrown, or dropped on each other or rolled or walked over on the floor or dropped from tailboards. Bombs equipped with shipping bands may be rolled with care. Separate-loading shell may be rolled, if the rotating band is protected from damage. Metal roller conveyors and trucks may be used except for hazardous explosives which may be ignited by sparks. Such explosives should be handled either by hand or with wooden or nonsparking conveyors.

(3) If the precautions prescribed herein are strictly complied with in handling ammunition containing the newer types of explosives, such as Composition B, pentolite, and tetrytol, it should be no more dangerous than the handling of ammunition loaded with TNT. High-explosive items with thin walls and high charge-weight ratio, require special attention to avoid denting the walls. Such items must not be handled on chutes or otherwise subjected to excessive impact.

(4) No tools or equipment so designed that steel or other spark-producing metal comes in contact with explosive materials will be used in handling hazardous explosives. Safety tools are required in box opening and repair. Such tools are constructed of wood or nonsparking or spark-resistant materials, as bronze, lead, beryllium alloys and monel metal, which, under normal conditions, will not produce sparks.

(5) Gasoline-powered lift trucks will not be used for handing exposed explosives, or be used in locations where exposed explosives are present. They must not be used in igloo magazines.

(6) Explosives and ammunition should not be exposed to moisture or dampness or to the direct rays of the sun for any long period. If it is necessary to leave boxes temporarily outside of magazines or cars, they should be covered with a tarpaulin so placed that there is free circulation of air through the pile.

(7) Ammunition will not be improvised, reconditioned, renovated, or salvaged within the magazine area unless the sites, buildings, or cars in which work is being done are devoted exclusively to such work and are specifically approved. Quantity-distance requirements in chapter 3 section II, must be observed.

(8) If explosives spill or sift from a leaky container, all work will be stopped until the explosives have been removed, and surfaces washed or desensitized as far as practicable.

161. FIRE PROTECTION.

a. General.

(1) Fire prevention is of the utmost importance. Many of the fires involving explosives and ammunition are preventable. It is the duty of all concerned in their handling to study the causes of fires and thoroughly inform themselves of the safety precautions that must be taken to prevent them.

(2) A great hazard in and around explosives is heat. Some explosives ignite at temperatures substantially lower than those required to ignite wood, paper, or fabrics, and ignition might result in explosion. Therefore, every effort will be made to maintain normal temperatures surrounding ammunition and explosives.

b. Causes of fires. Fires in magazines and magazine areas may be due to a number of causes, of which the following are most common:

(1) DRY GRASS, LEAVES, AND UNDERBRUSH. These may be ignited by sparks from locomotives, by smoking or the careless use of matches and camp fires.

(2) DETERIORATION OF EXPLOSIVES AND AMMUNITION. This normally occurs at such a slow rate that most explosives and ammunition remain serviceable for many years. However, under unfavorable conditions, explosives and ammunition may produce heat so fast that it cannot be dissipated, causing the explosive or ammunition to burst into flame. Where the explosive or ammunition is confined, an explosion or detonation may result.

(3) REPACKING, RENOVATION, AND SALVAGE OPERATIONS, NOT PROPERLY SUPERVISED AND CONDUCTED IN ACCORDANCE WITH RECOGNIZED SAFETY STANDARDS. The most common sources of trouble are excessive quantities of powder and loose explosives, accumulation of waste paper, broken boxes, unauthorized use of spark-producing tools, defective machinery, faulty electrical equipment, etc., and failure to provide the proper barricades and firebreaks necessary to prevent the spread of fire from one operation to another.

(4) LACK OF TRAINING, OR VIOLATIONS OF INSTRUCTIONS OR WRITTEN REGULATIONS. The most common violations involve smoking, carrying matches in forbidden areas and buildings, or tampering with explosives or ammunition, particularly grenades or fuzes.

(5) FAILURE TO UNDERSTAND AND CAREFULLY OBSERVE THE SAFETY PRECAUTIONS PRESCRIBED FOR DESTROYING EXPLOSIVES AND AMMUNITION. The most frequent source of trouble is flying fragments which cause grass fires or explode piles of explosives and ammunition awaiting destruction.

(6) SPARKS. These may be caused by striking iron or steel nails or metal containers with iron or steel tools, or by nails in shoes striking flint, pebbles, sand or grit, or nails in the floor. Such sparks, small as they are, have caused disastrous explosions of black powder or the dust of other explosives which ignite easily. This hazard is the basis for requiring tools of brass, copper, or other nonsparking materials, cleaning mud and dirt from shoes before entering magazines, and wearing safety shoes approved by the Chief of Ordnance, when exposed explosives are present.

(7) STATIC ELECTRICITY. Charges of static electricity can be accumulated on a person and on explosive material such as smokeless powder. The discharge of static electricity is considered a serious hazard in the presence of certain exposed explosives, dust and air mixtures, and inflammable vapor-air mixtures. Processing equipment for such materials subject to static discharge should be electrically grounded; benches and flooring should be covered with electrically grounded conductive material; and personnel provided with safety shoes of authorized types. Cushioned metal chairs should not be used in locations where explosives or highly inflammable materials are present.

(8) FAILURE TO CONTROL SAFELY THE USE OF HEAT- AND FLAME-PRODUCING EQUIPMENT. Such equipment may be that used in maintenance work on buildings or that contaminated with explosive material.

(9) LIGHTNING. *Lightning may strike* buildings, trees, or other objects in or near explosive areas. All buildings and structures in storage areas should have complete lightning protection which meets the requirements of the Chief of Ordnance.

(10) ELECTRIC TRANSMISSION LINES. These are often blown down or come in contact with combustible materials.

(11) LACK OF A PROPER MUFFLER, or the use of a muffler cutout on motor vehicles can cause fires.

c. **Fire-prevention regulations.**

(1) Matches or other flame- or spark-producing devices will not be permitted in any magazine area or explosives area except by written authority of the commanding officer.

(2) Smoking is prohibited in any magazine or magazine area, or around cars, wagons, motor trucks, or boats in which there are explosives or ammunition. Buildings or locations for smoking may be designated outside restricted area, subject to following limitations that:

(*a*) Smoking will not be allowed in locations closer than 60 feet to buildings containing explosives, ammunition, or hazardous materials.

(*b*) Windows and doors of buildings close to explosives or ammunition areas which are approved for smoking will be fitted with wire screens.

(*c*) Suitable receptacles must be provided for cigarette and cigar butts and pipeheels.

(*d*) Only permanently installed electric lighters of approved types shall be used in the building.

(*e*) Hand fire extinguishers, sand boxes, and water barrels with buckets will be furnished as required for each room or building in which smoking is permitted. Persons whose clothing is contaminated with explosives or other hazardous materials will not be permitted in such areas.

(3) All flashlight or storage-battery lamps used in buildings containing explosives or flammable vapors shall be types approved as "permissible" by the United States Bureau of Mines or by a similarly recognized testing laboratory for that specific type of exposure.

(4) If gasoline or electric-powered lift trucks are used for transporting explosives or ammunition, the requirements of the Chief of Ordnance will be complied with.

(5) Where it is necessary to install power transmission and service lines in the vicinity of buildings containing explosives, the distance of the lines from the buildings will be greater than the distance between the poles which support the lines. This is to prevent broken wires from hitting the building. Overhead transmission line must not pass within 50 feet of the buildings. In future installations, power lines and services entering buildings containing explosives must be placed underground within 50 feet of the building.

(6) Vegetation in the form of grass, undergrowth, weeds, etc., which is or may become a fire hazard will be controlled by the use of chemical weed killer or by mowing, plowing, cutting, livestock grazing or, in calm weather and with proper control, by burning. Chemical weed killers should not contain chlorates or other substances which may ignite spontaneously under hot dry conditions. Burning should not be permitted within the 50-foot space specified in the paragraph below. Brush, grass, wood, etc., in piles, will not be burned within 200 feet of a magazine. Reserve supplies of dunnage should not be stored haphazardly inside the magazine area and in no case within the 50-foot firebreak around the magazine.

(7) A firebreak at least 50 feet wide and as free as practicable from inflammable material will be maintained around each above-

ground magazine. The earth adjacent to and extending over igloo magazines will be cleared of dry debris. Firebreaks around the entire magazine area and at other places within the magazine area, such as along railroad tracks, will be maintained wherever necessary.

(8) Locomotives, trains, and other rail vehicles used in the magazine area will be so equipped that the communication of fire is prevented insofar as practicable. Inspections will be made regularly to insure that safe conditions are maintained.

(9) Gasoline or other highly inflammable liquids will not be used for cleaning purposes. Solvent, dry cleaning, Federal Specification P-S-661a (Quartermaster issue) will be used in all cases where solvents of this nature are required. Dry-cleaning solvent is inflammable differing principally from gasoline in having a higher flash-point. When handling dry-cleaning solvent, AR 850-20, "Precautions in Handling Gasoline", will be observed in all cases. This regulation does not prohibit the use of trisodium phosphate, trichloroethylene, tetrachloroethane, or similar cleaning or degreasing substances for cleaning operations. However, since many of the industrial organic solvents have pronounced toxic properties, particularly in vapor form, care must be taken in the selection of degreasing substances and apparatus. Adequate ventilation must be provided.

(10) Automobile parking should be regulated so that automobiles will not be parked closer than 25 feet to buildings or fire hydrants.

(11) Ammunition boxes, containers, dunnage, and lumber must be stacked in an orderly manner when in the vicinity of explosives renovation, handling, or storage operations. Stacks of such combustible materials must be limited to small areas between fire breaks. This is a means of limiting the spread of fire insofar as it is practicable considering the available space, available means of extinguishing fire, and the probability of fire occurring. Under average conditions, areas under solid stacks of such materials should be limited to 1,500 square feet separated from other similar areas by 25-foot fire breaks in which vegetation has been cut and controlled. Bulk stacking of such materials should not be closer than 500 feet to magazines or other buildings containing high explosives, except that working quantities within practicable limits may be stacked in the vicinity of explosive magazines, but not closer than 50 feet. Water barrels and pails should be liberally provided in such areas with which to extinguish incipient fires.

(12) The above rules will be supplemented by such additional rules as the commanding officer deems necessary to secure adequate protection against fires.

d. Fire-fighting facilities.

(1) A fire involving explosives or ammunition may result so quickly in an intense conflagration or explosion that means for immediately attacking the first small blaze detected are vitally important. Immediate use must often be made of hand equipment. In addition to organized permanent facilities, the following types of fire-fighting equipment may be used to good advantage:

(a) Barrels and buckets filled with water, placed at each magazine. If this class of fire-fighting equipment is always maintained so that it can be depended upon in case of fire, it is a valuable fire protection. However, in the summertime the barrels must be frequently refilled, and in freezing weather calcium chloride or salt must be added. Buckets deteriorate rapidly unless they are frequently painted or protected from the weather, and are blown about by windstorms if they are not securely fastened in place. Fastening devices must be releasable at will.

(b) Boxes and buckets filled with sand, and shovels.

(c) During freezing weather, trucks and trailers filled with water will require heated storage. Provision should be made for rapid movement of the equipment to the scene of the fire.

(d) To combat grass or forest fires in or near the magazine areas, there will be maintained at suitable locations an adequate supply of gunny sacks, brooms, rakes, hoes, or other similar equipment. This equipment should be regularly inspected and protected against theft or unauthorized use.

(2) When explosives and ammunition are being handled or work is being done in the immediate vicinity of such stores, there will be present, ready for immediate use, two chemical or other type hand fire extinguishers. It is not required that these be permanently located in a magazine, although this should be done if practicable, but it is required that these be in an accessible location. Serious fires may be avoided by the prompt use of hand fire extinguishers. They are required primarily for use on incipient fires in inert combustibles such as grass, grease, oil, dunnage, etc., which if not extinguished might reach explosives. Personnel other than the one using the extinguisher should seek safety immediately, reporting the fire en route.

(3) The water distribution system should be protected by sectional control valves so that damaged sections of the main can be cut off without impairing the operation of the remainder of the system. Water mains should not be located under railroads or roads used for conveying large quantities of explosives or ammunition, as a

detonation may cause a breaking of the main. When it is necessary to have water mains pass under railroads or roads, cars or trucks loaded with explosives or ammunition will not be permitted to remain over these water mains longer than necessary for continuous travel and suitable signs will indicate such location. Water mains should be protected with cut-off valves on both sides of the railroad or road. Fire hydrants should be connected to a looped grid system so as to provide supply from more than one direction.

(4) The duties of guards, firemen, military personnel, and others will be so arranged that an adequate fire-fighting force will be available at all times.

(5) Fire drills and inspections will be carefully conducted to insure that fire-fighting forces understand their duties and that fire-fighting equipment functions dependably under actual working conditions. Frequently, hose not tested to working pressures burst when most needed.

162. FIRES IN WHICH EXPLOSIVES ARE INVOLVED.

a. Fires which may occur in buildings or magazines containing explosives will vary in intensity and effect, depending on the material involved in the fire. Certain explosives will detonate or explode immediately on contact with a spark or flame, or when subjected to frictional heat or concussion. Fire may or may not result from the detonation. Some explosive substances may burn freely while others will be subject to explosion while burning, or will develop such intense heat as in the case of smokeless powder, that fire-fighting efforts will be impossible. Fire-fighting forces should be well acquainted with the hazards and best methods of combating fires in all such materials under their protection.

b. With certain exceptions water will be used as the fire-fighting medium. Generally speaking, large volumes of water spray or fog produced by nozzles designed for the purpose will prove more efficient than solid streams of water for extinguishing fires of an explosive nature. Solid streams of water at high pressures should be used when consideration for the safety of fire-fighting personnel makes it impossible to approach the seat of the fire. In fire-force training programs, emphasis should be placed on laying as many hose lines as possible, in order to surround and confine the fire.

163. GENERAL INSTRUCTIONS IN COMBATING FIRES INVOLVING EXPLOSIVES.

a. General instructions which will be followed in combating any fires involving explosives and ammunition are as follows:

(1) When a guard or watchman discovers smoke coming from a closed magazine, or other evidence that a magazine is afire, he will give the alarm as quickly as possible. He will not enter the burning building since he may become trapped and be unable to give the alarm. If the fire is discovered in the grass or other combustible material surrounding the magazine, the alarm should be given immediately and the guard should then do all that is possible, using extinguishers, water from nearby water barrels, or grass fire-fighting tools, to extinguish or control the fire until the fire-fighting forces arrive.

(2) When a workman or other person discovers a fire in a building where people are working and explosives are present, personnel present will be evacuated by suitable signal in accordance with prearranged plans. At least one responsible messenger will be dispatched in the direction from which the fire department is expected, to inform them of the nature and extent of the fire. The officer in charge of fire fighters will not permit the advance of his men to such a fire unless he has what he believes to be accurate information as to the existing conditions and concludes therefrom that he is justified in doing so (par. 165).

(3) Fire-fighting forces will attack a grass fire vigorously and endeavor to extinguish it even when it is close to a magazine. If a fire has actually gained headway in a magazine, fire-fighting forces should either combat the fire or seek the nearest suitable protection, depending on the type of ammunition or explosives within the magazine (par. 165).

164. IDENTIFICATION OF MAGAZINES. As a means of providing a guide to fire-fighting forces, the Ordnance Department divides explosives into four groups in accordance with the general burning or explosive characteristics of the materials and the relative danger encountered in fighting fires in which they are present. The four groups are identified by symbol numbers 1 through 4, the hazard to fire fighters increasing progressively with the numbers. Ordnance regulations require that ordnance buildings containing hazardous or explosive materials, except igloo magazines, be plainly marked with the symbol number (no less than 24 inches high) of the most hazardous material contained therein, as described in paragraph 165.

165. FIRE HAZARD GROUPS AND FIRE-FIGHTING PROCEDURES.

a. **Symbol 1.** This group consists of Classes 1, 11, and 12 ammunition; metallic powders in ICC approved shipping containers; and chlorates, perchlorates, peroxides, nitrates, and other inorganic oxidizing agents in sealed containers. While these materials are principally fire hazards and fires in which they are involved may be fought, minor explosions may be expected so that extreme caution must be exercised in accordance with the following:

(1) SMALL-ARMS AMMUNITION. Shipping containers of small-arms ammunition, especially when tracer and incendiary rounds are included will continue to burn fiercely even after the magazine has been consumed. Personnel attempting to fight the fire after fire has reached the ammunition itself must be shielded from light hot missiles which may be expected to travel up to 200 yards at a velocity of approximately 200 feet per second. Sheet metal covered wooden shields can be used and moved to various vantage points. When practicable to use water spray, it will be found very effective in extinguishing such fires.

(2) Oxidizing agents are not flammable in themselves, but when heated in a fire involving combustibles, give off oxygen which greatly facilitates burning. Fire fighters should be provided with suitable masks to guard against poisonous fumes resulting from such fires. Cooling or drowning with large quantities of water may serve to control or extinguish these fires, but after the fire has gained considerable headway, fire-fighting efforts may, of necessity, be confined to protecting adjacent property as much as possible.

(3) CHEMICAL AMMUNITION. For fires involving chemical ammunition containing blistering agents, all fire fighters will be protected by masks and complete protective clothing. If practicable, such fires will be fought from the windward side. All unprotected personnel downwind will be evacuated and civilian inhabitants warned. Fires involving toxic chemicals will be fought with similar precautions except that the danger area downwind is less. Fire fighters will be protected with suitable masks. In fires involving HC smoke mixture, attempts should be made to remove and segregate the burning containers. When a relatively small amount of HC smoke mixture is involved in a fire, it can be "drowned" with water. Water will also serve to cool adjacent containers to prevent further spread. Unless water can be applied in large amounts in relation to the actual HC smoke mixture which is exposed and burning, the efforts to fight the fire will be ineffective and the material may explode. Fire fighters should not enter magazines containing a high concentration of HC smoke unless adequately protected by oxygen masks and supplied with life lines.

b. Symbol 2. This group consists of Class 3 ammunition and explosives.

(1) Personnel discovering such a fire should give the alarm and attempt to put the fire out with the equipment on hand, provided the fire is in the incipient stage. The fire-fighting organization should fight the fire if there is a possibility of extinguishing it. If this does not seem possible, the building should be abandoned and fire-fighting efforts concentrated on preventing the spread of the fire. Limited explosions may be expected from fire in these materials. Personnel should exercise due precautions to prevent injury to themselves and their equipment.

c. Symbol 3. This group consists of Class 2 smokeless powder in bulk shipping containers and Class 2 pyrotechnic material.

(1) Unless the fire is of a minor nature and does not involve the explosive itself, and there is a chance of controlling it, fire-fighting should be confined to preventing the spread of the fire to other buildings. These materials burn with intense heat and personnel and fire-fighting equipment should be adequately protected.

(2) PHOSPHORUS. In fires involving phosphorus, personnel entering magazines with portable extinguishers will have life lines attached in order to be able to find their way out through the heavy smoke. It should be remembered that phosphorus will stop burning only so long as it is under water; when exposed again to the air, it ignites spontaneously.

(3) PYROTECHNICS. When fire involves pyrotechnics and large quantities of magnesium-type incendiaries, fire fighters should confine efforts to protecting adjacent buildings and magazines. Water may accelerate burning and cause explosions which may scatter burning material. The use of carbon dioxide and carbon tetrachloride extinguishers on such fires will create poisonous gases. Small fires involving 50 pounds or less of magnesium can be smothered with dry inert material which is powdered or granular, such as hard coal, tar, pitch, graphite (preferably coated to eliminate dust), rust-free cast-iron borings, soft coal, talc, salt, or sand. Asbestos, sand, salt, and talc are not inert in magnesium fires, but may be used dry if the fire is small. The powder should be placed over the burning material so as to cover it to a depth of one inch or more. It should not be disturbed until the magnesium has cooled except when the fire is on a floor of flammable material, in which case, after the fire is covered, a two-inch layer of extinguishing powder should be put on the floor beside the fire and the burning material raked onto the insulating layer and resmothered.

d. Symbol 4. This group includes Classes 4, 5, 6, 7, 8, 9, and 10 ammunition and explosives.

(1) Every effort should be made to prevent a fire from reaching this class of material, which is especially hazardous. If a fire occurs in such a magazine when personnel are present, they should attempt to put the fire out with the equipment at hand, providing it has not actually reached the material and there is a good chance of putting the fire out. Otherwise, they will evacuate the magazine and take cover. If fire breaks out in a magazine containing high explosives, fire-fighting forces will not immediately approach the fire. Unless specific information is available either from one who was present when the fire was discovered or from intimate knowledge of the construction of the building and location of the explosives indicating that it is safe to approach the fire, fire-fighting forces will remain a thousand feet distant where up to 50,000 pounds of high explosives are involved, or proportionally greater distance up to 2,000 feet for 100,000 pounds of high explosives, until explosions have occurred, indicating the probable destruction of the explosives present. Fire-fighting forces and their equipment must not be exposed to unnecessary risk where these materials are involved. Demolition or general purpose bombs, and antitank mines are liable to detonate en masse, and propelling charges may explode, producing heat that may blister the paint on buildings 500 feet away. Bulk high explosives packed in boxes will usually burn quietly, but may detonate. Black powder, photoflash bombs, smokeless powder in bulk, and unpacked propelling charges, explode or flash so quickly that there is no time to do anything to save the magazine involved. In almost every instance, the efforts of fire fighters will be confined to preventing fire from spreading to adjacent buildings or magazines.

166. GUARD PROTECTION.

a. Magazines and areas in which there are explosives and ammunition will be guarded adequately at all times. Magazine areas should be protected by non-climbable fences, entrances to which will be locked unless guards are stationed at them. Special precautions will be taken to guard areas which are not protected by a suitable fence.

b. Guards, and others in charge of explosives and ammunition, will be thoroughly instructed in the hazards due to fire and explosions and the safety precautions to be taken. They will be instructed that their most important duty is to protect explosives and ammunition against fire. Alarms will be given with the greatest possible speed so as to start action instantly. Serious fires and explosions have been avoided by prompt action of fire-fighting forces. After giving the alarm, guards will exert every effort to hold the fire under control until the fire-

fighting forces arrive, except that should a fire occur in a closed magazine, they will not attempt to enter the magazine.

c. Hunters either inside or outside a magazine area who are found using fire-arms in a manner which may endanger stores will be reported. Hunters in such areas should be warned not to shoot.

d. Except under emergency conditions, guards protecting ammunition and explosives, will not be armed with rifles. Generally, shotguns are recommended for guard purposes. Many military explosives are not initiated by low velocity projectiles, but any bullet striking explosives may cause a serious fire and/or explosion. Guards protecting explosives or ammunition will be instructed regarding the danger of firing in the direction of a magazine.

e. Guards should be instructed to make a prompt report of the following:

(1) Any unusual occurrence in or near a magazine area.

(2) Grass or forest fires in areas adjacent to the magazine area.

(3) Dangerous practices of personnel working in magazines or explosives areas, such as smoking, unauthorized use of fire equipment, and tampering with ammunition or electrical equipment.

(4) Unlocked magazines doors and shutters, defective telephone and electric wires, and openings in fences surrounding the magazines.

Section II

STORAGE

167. GENERAL.

a. In these general precautions, the word "magazine" is intended to cover any space containing a supply of explosive material, and includes such places as an above-ground magazine, earth-covered igloo-type magazine, railroad car, the body of a motor truck, a temporary shelter, or a stack.

b. General storage regulations are contained in AR 700-10. Regulations for ordnance establishments are contained in the Ordnance Safety Manual (O.O. Form No. 7224), and Ordnance Department Safety Bulletins which supplement that manual. Regulations and instructions in this section are for Zone of Interior Class I, II and III installations which store limited quantities of explosives and ammunition. Larger quantities should be stored in accordance with regulations prescribed for Class IV installations under the control of the Chief of Ordnance. Regulations for overseas installations are contained in FM 9-6, "Ammunition Supply", and FM 9-20, "Ordnance Ammunition Company, Ordnance Ammunition Battalion."

168. GENERAL STORAGE PRECAUTIONS.

a. Explosives and ammunition should be stored in buildings designed, designated, and isolated for the specific purpose. Explosives and ammunition will not be stored in buildings which are used for other purposes such as basements or attics of barracks, company supply rooms, or general storehouses. When specially constructed magazines are not available, the buildings used must afford good protection against moisture and dampness, and have means for adequate ventilation. They must be floored with approved material and may not be heated by open fires or stoves.

b. Ammunition should be stacked by lot number in stacks arranged so that no obstacle is offered to free circulation of air beneath and throughout the stack. When more than one lot is stored, all items or containers of a lot should be stored together and the line of separation between lots clearly indicated. Lots of ammunition should never be mixed at random. The tops of ammunition stacks should be below the level of the eaves to avoid the heated space directly beneath the roof. The bottom layer should be raised off the floor about two inches. Dunnage should be level; if necessary, shims or wedges should be used. Stacks should not be so high that ammunition or its containers in the lower layers will be crushed or deformed. Partly filled boxes should be fastened securely, marked, and kept on the top of the pile.

c. Boxes, cases, and other containers of ammunition should be clean and dry before being stored. Ammunition containers should not be opened in a magazine. They should not be stored after having been opened unless they are securely closed, except that ammunition and explosives in damaged containers in process of being repaired may be stored overnight in magazines. When it is necessary to store ammunition and explosives overnight in damaged containers, they should be separated from serviceable ammunition. Repair or change of container will not take place in or within 100 feet of a magazine containing explosives.

d. Rounds or components will not be kept loose in a magazine. No empty container, excess dunnage, or tools should be permitted to remain in a magazine. No oily rags, paint, turpentine, etc., will be left in a magazine containing ammunition or explosives.

e. Improvised ammunition such as "Molotov Cocktails," hand grenades of nitrostarch, commercial fireworks intended to simulate ammunition, and other nonstandard devices should be prepared in an isolated area or building free of loose explosives and waste paper or other combustible material. All such work should be performed under direct supervision of competent experienced persons. The quantity of explosives present should be the minimum necessary for the operation, which should be carried out in conformity with quantity-distance and inhabited-building distance requirements for class 10 ammunition given in paragraph 172. The number of persons permitted at or near the operations should be kept to a minimum. When a surplus of such material must be stored, under no circumstances should it be stored in a magazine with other explosives or ammunition because the items are generally of substandard construction and the explosive content may be of such a nature as to present a serious hazard in storage and handling.

f. Inflammable liquids and ammunition should not be stored together or close to each other. Ammunition should be separated by the inhabited-building distance (par. 172) from handling or storage of inflammable liquids to prevent fires originating in one area spreading to another.

g. Chemical ammunition will be stored separately, so placed that each container may be inspected for leaks and may be easily removed.

h. Ammunition assembled with tracer pyrotechnics, propelling charges, and other ammunition items, should be stored under the best cover available, preferably in a building providing protection against dampness and having adequate ventilation. Tracer ammunition is subject to rapid deterioration if damp and may ignite spontaneously.

i. Truck motors should not be started while the magazine door is open. However, a motortruck may approach a magazine without the necessity of closing the magazine doors provided the following requirements are complied with:

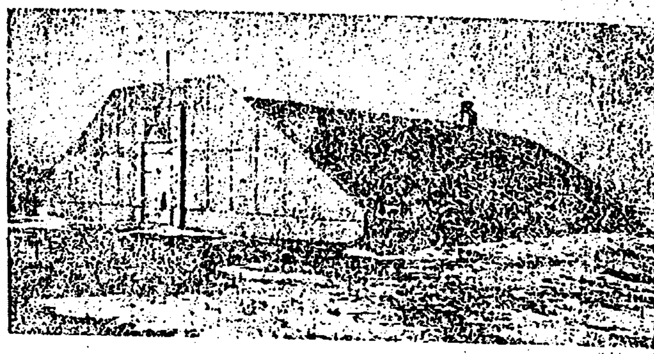
(1) The motor exhaust is equipped with an effective spark- and flame-arresting device in the exhaust line.

(2) No exposed explosive material is being transported or handled.

(3) No explosive material is located on the platform or otherwise outside the magazine or truck while the engine is running.

169. OUTSIDE STORAGE.

a. Outside storage of explosives and ammunition is neither desirable nor recommended, and must be resorted to only as an emergency expedient. When such storage must be employed, bombs and separate-loading shell will be given preference over packaged ammu-



RA PD 89380

Figure 153 — Igloo-type Magazine

nition. In order that outside storage of explosives and ammunition may be kept to a minimum, full advantage must be taken of the cubic capacity of all magazines, within the limits prescribed by this manual. When it becomes necessary to utilize outside storage within the continental United States, it shall be in accordance with the distance requirements of paragraph 172.

b. Sites for outdoor storage will be carefully chosen to avoid exposure to power lines. Ammunition should not be located adjacent to reservoirs, underground water mains, electric cables, or sewer lines. Outdoor storage should be located where there is good surface drainage. Outdoor storage shall conform to quantity-distance requirements for above-ground magazines.

c. The supporting timbers or platforms upon which ammunition is stored should be well constructed to prevent falling, sagging, and shifting of the ammunition.

d. Crated and packaged ammunition, smokeless powder, pyrotechnics, and bulk high explosives should not be stored outdoors. Efforts should be made to avoid the necessity for outdoor storage of any type of ammunition.

e. Care will be exercised in closing openings in loaded bombs and other ammunition which have not been completely assembled. Temporary plugs used as closures should be set down against suitable washers so that dirt and moisture cannot enter.

f. It is advisable to cover piles of bombs and shell with some type of waterproof material to guard against direct exposure to the atmosphere, provided that adequate ventilation is assured.

RA PD 89376

Figure 154 — Standard Magazine

g. Frequent inspections shall be made to locate sagging piles and to detect accumulation of trash between or under the stacks.

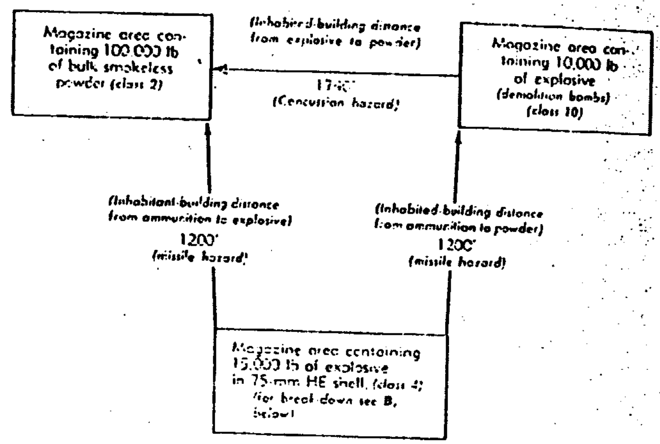
170. TEMPORARY STORAGE AND HOLDING YARDS.

a. **Temporary storage yards.** In some cases, it may be found necessary to hold cars of ammunition for a period of more than 24 hours but not exceeding 2 weeks. The cars are considered as above-ground magazines. Existing tracks may be utilized provided quantity-distances for above-ground magazines are complied with. The cars should be grouped so that each group is limited to 250,000 pounds of high explosive, and so that groups are separated from each other by a minimum distance of 800 feet. If the full distances cannot be provided, then groups may be spaced 400 feet apart in all directions, provided one or more cars of inert materials or of small-arms ammunition are spotted between the groups.

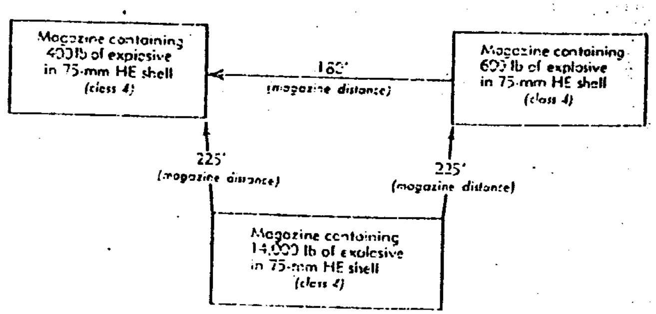
b. **Holding yards.** The cars on the tracks are considered as above-ground magazines. To provide flexibility of storage, yards should be laid out so that the tracks are 400 feet apart with a barricade between the tracks. The cars shall be in groups so that each group is limited to 250,000 pounds of high explosive and the distance between groups is 800 feet unbarricaded or 400 feet barricaded.

171. MAGAZINES AND MAGAZINE AREAS.

a. **Magazine areas.** It is essential that explosives and ammunition be segregated in an area specifically set aside for their exclusive



A — Inhabited-building distances must separate magazine areas.



B — Magazine distances must separate magazines within a magazine area.

RA PD 89389A

Figure 155 — Spacing Magazines and Magazine Areas

storage. This area need not be large, but it is important that it be segregated from barracks, hospitals, administration buildings, public highways, inhabited buildings and railroads. Magazine areas should be laid out with regard to access from more than one direction; roads and tracks should be looped. Magazines should not be located over important water mains or close enough to important power lines to damage them in case of an explosion.

b. **Magazines.** Magazines (figs. 153 and 154) should be designed, constructed, and located with special attention to the class of materials to be stored therein and should comply with the following general requirements:

(1) Magazines should be constructed of materials which, in the event of an explosion, will not form dangerous missiles or firebrands. Magazines should not be located upon continuous rock strata because of the possible transmission of shock wave to excessive distances.

(2) Magazines should be fireproof unless the nature of the hazard permits the use of a frame building covered with fire-resistant material such as corrugated sheet asbestos. Where it has been necessary to construct concrete-floored, wooden-arched, earth-covered igloos in lieu of the more permanent type of construction (fig. 153), exposed wooden portions of these temporary structures should be covered with a fire-resistant material such as sheet rock, asbestos, or a comparable product. Provision should be made to cover as much as possible of the front and rear, as well as the sides, of these igloos with earth as an extra precaution. With this type of construction, additional care should be taken to prevent seepage of moisture into the structure.

(3) Each magazine should be provided with ventilators which should be screened against sparks.

(4) All doors should be made to fit tightly so as to seal against sparks, dust, and dirt, and should be fire-resistant.

(5) Magazines should be built on well-drained ground.

(6) Magazines must be located so as to be accessible to adequate transportation facilities.

(7) Magazines must be protected against lightning by an efficient lightning protection system. Details and specifications of lightning protection systems prescribed for ordnance establishments are contained in drawings prepared by the Ordnance Department.

c. **New construction.** The construction of new buildings or magazines for the storage of explosives and ammunition will be in accordance with drawings and specifications for magazines prepared by the

Ordnance Department. Lay-out plans for proposed magazine areas and their location on a reservation must be approved by the Chief of Ordnance.

d. **Arrangement of magazines.** In arranging the storage of hazardous material in above-ground (not concrete igloo-type) magazines, the following general principles should be followed as guides for preventing the spread of damage throughout an entire area in case of a fire or explosion in one part of the area:

(1) Smokeless powder or other materials which may become hazardous if the buildings in which they are stored are damaged or demolished, or which may be ignited or exploded by burning or exploding missiles, should be stored at inhabited-building distances from high-explosives and ammunition magazines.

(2) Bulk high explosives or bombs should be stored so they will be protected from missiles which may be thrown from ammunition magazines as a result of explosions. This principle requires that a magazine in which bulk explosive is stored be at missile distance from a magazine in which ammunition is stored.

(3) In applying the principles set forth in (1) and (2) above, magazines situated between areas in which ammunition, high explosives, or smokeless powder are stored may be used for the storage of such other material as will minimize the danger of fires or explosives progressing from area to area (fig. 155).

e. **Care and maintenance of magazines.** Regular inspection will be made of each magazine and magazine area to see if repairs are needed, and to insure that the general safety regulations set forth in this manual, particularly those which refer to the cleanliness of magazines and elimination of fire hazards, are strictly observed.

(1) To insure continuous and reliable protection, lightning protection systems should be inspected not less than twice a year. Once yearly, each system should be tested electrically. Guidance for the tests and the equipment with which to make them may be obtained from the Office of the Chief of Ordnance.

(2) Roofs must be maintained in the best possible condition and ventilators screened against sparks. There must be no unprotected openings around the foundation and no cracks in the walls. Doors must be tight and sparkproof.

(3) Interiors of magazines must be clean. Paint, oil, gasoline, waste, rags, and other such extraneous inflammable material should not be left in magazines.

(4) Floors must be free of grit and such stains as those caused by exuding shell or dynamite. Exudate from shell should be removed by scrubbing with hot water. Exudate or oily stain from dynamite must be removed by scrubbing with hot water, acetone, or other suitable solvents.

(5) The 50-foot firebreak must be kept free from inflammable materials. Fire-fighting equipment such as water barrels and sand boxes must be kept full and ready for use.

(6) Magazines must be kept locked, except when opened for necessary operations or inspection.

(7) When open, a magazine must be in the personal care of an officer or other responsible person other than the nearest sentry.

(8) Keys must be under the supervision of the individual responsible for them.

(9) When leaving the magazine, the person in charge of operations must make sure that all doors and shutters are securely locked.

(10) A magazine placard, "Storage and Care of Explosives," O.O. Form No. 5991, must be posted in every magazine, positioned so that it will be conspicuous to all working personnel inside.

f. **Repairs to magazines.** Magazines will be repaired under direct supervision of a competent person who will decide whether or not the contents of the magazines are to be removed while repairs are made. Under normal conditions, roofs, lightning rods, ventilators, doors, etc., may be repaired, and minor repairs may be made to the interior of the magazine without removing the contents. *This does not apply to magazines containing bulk explosives.* When magazines are repaired, the general safety precautions set forth in this manual will be complied with. In addition, the following special regulations will be observed:

(1) Work will be done by careful, experienced workmen.

(2) The floor in the vicinity of the work will be swept and any stains scrubbed with hot water.

(3) No work requiring soldering, melting of asphalt, or use of a blowtorch will be done in a magazine containing explosives or ammunition.

(4) No repairs will be made to the interior of a magazine containing bulk explosives until all explosives have been removed and the interior washed with water.

(5) All persons should be searched for matches before being allowed to enter any magazine.

(6) All magazines should be carefully swept after repairs have been completed, all tools should be removed after repairs have been completed.

(7) The magazine will be inspected by competent authority after repairs have been completed.

172. QUANTITY-DISTANCE CLASSES AND TABLES.

a. To reduce to a minimum the hazards and risks due to fire and explosion, these regulations prescribe:

(1) The distances which will be maintained between magazines at military establishments and public highways, public buildings, public railways, and inhabited buildings.

(2) The distances that will be maintained between magazines.

(3) The maximum quantity that will be permitted in any one magazine.

b. These precautions not only protect persons and property in the territory adjacent to military establishments, but also reduce to a minimum the possibility of any explosion involving large masses of explosives and ammunition, and limit the quantity of military supplies that may be lost in any one explosion.

(1) In time of war, military requirements may make full compliance with safety regulations especially difficult. Since the purpose of the regulations is to reduce to a minimum the losses of personnel and military stores, and to maintain the full utility of military establishments, the compliance with explosives and ammunition regulations is considered highly important in war time.

(2) In time of peace, the quantity-distance tables set forth below will be strictly complied with except when subject to reductions under special conditions as indicated below and in case of existing emplacement magazines at harbor-defense installations. Such harbor-defense magazines may be used for the storage of ammunition pertaining to the armament of the emplacement and not in excess of its war reserve allowance. Magazines of emplacements from which the armament has been removed or has become obsolete may be used for the storage of any class of ammunition and explosives, provided the quantity-distance tables are complied with.

(3) Buildings at military establishments where personnel are regularly located will be placed at inhabited-building distances from magazines except when the buildings are used for operations incident to the magazine area.

c. The distances specified in these tables offer protection against structural damage and most missiles. Occasional missiles which travel a mile or more are not considered because of their rarity, especially when the amount of material involved in one explosion is limited by keeping piles small and spacing them so as to limit the explosion to one pile. It will be noted that the distances specified in the tables are based not on the total amount of explosives in the magazines, but upon the missile hazard and the amount that may be involved in one explosion. The specified distances may be changed under the following special conditions:

(1) In storage of classes 8, 9, and 10 items, when a magazine is effectively barricaded or screened from other buildings, magazines, railway, and highway, the distances may be reduced one-half. Effective screening can be obtained by utilizing natural features of the ground or by an artificial barricade at least 4 feet from the magazine, at least 3 feet thick at the top, at least high enough so that the straight line extended from the top of the side wall of the magazine to the top of the barricade will pass above any part of a building to be protected, and at least 12 feet above any public highway or public railway. Artificial barricades should consist of earth or sand fill, with not more than 15 percent of stones on ground, which should pass through 1-inch openings.

(2) Magazines of standard earth-covered concrete-arch type (igloo type) and emplacement magazines, are considered barricaded on all sides except that of the entrance, which side may be barricaded if local conditions require.

(3) Harbor defense emplacement magazines in a group, being separated from each other by substantial dividing walls, need not comply with the intermagazine distances. However, each magazine, as a unit, must comply with the table distances for inhabited building, public highway, and public railway.

(4) Where the construction of the magazine is such as effectually to stop the missiles resulting from an explosion in another magazine, the distances between the two may be based upon the total explosives material in ammunition components in the latter magazine, considered as class 9 instead of the distance prescribed for the class stored. Such magazines are the standard earth-covered concrete-arch type (igloo type) and emplacement magazines. The quantity to be considered will be the total quantity to be stored in the magazine except where specific cases are excepted in step (5), below.

(5) SPECIAL REQUIREMENTS FOR SPECIFIC CLASSES OF AMMUNITION. When ammunition of Classes 6 and 7 are stored in igloo magazines in accordance with Ordnance drawings, the aisle width is not sufficient to preclude mass detonation. Therefore, quantity-distance

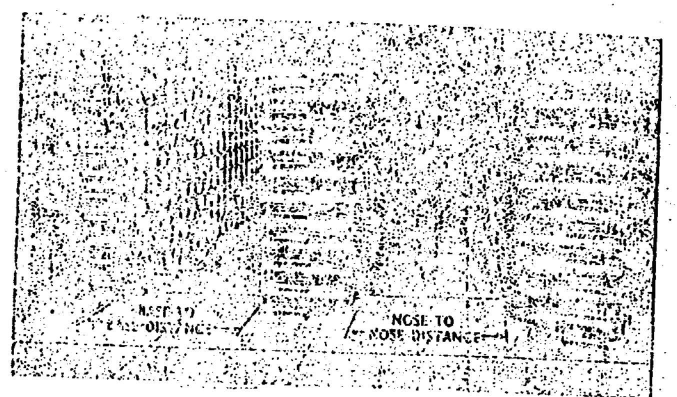


Figure 156 — Method of Stacking Shell in Above-ground Magazine Storage

requirements for Classes 6 and 7 when so stored including the maximum permitted in each magazine, shall be those prescribed for Classes 9 and 10. In above-ground storage magazines, the quantity-distance tables for ammunition and ammunition components of Classes 6 and 7 are based on the assumption that on initiation mass detonations will not occur, and that the detonation at any one instant will be limited to the amount contained in one stack and that the missile distance is the controlling consideration. Ammunition of Class 6 stored in above-ground magazines shall be spaced in stacks containing not over 5,000 pounds of explosives each, with stacks spaced at a minimum of 2 feet apart. Ammunition of Class 7 stored in above-ground magazines shall be placed in stacks containing not more than 15,000 pounds of explosives each and spaced in accordance with Ordnance Drawing 19-48-12. See figures 156, 157, and 158. If stacking requirements are not satisfied in the storage of Classes 6 and 7 material, it will be assumed that, on initiation, all ammunition in one magazine will detonate en masse and that the quantity-distance requirements, including the maximum permitted in each magazine, shall be those prescribed for Classes 9 and 10.

d. **Definitions.** Terms used in the following tables are defined as follows:

(1) INHABITED BUILDING. Any building or structure occupied in whole or in part as a habitation for human beings, where people

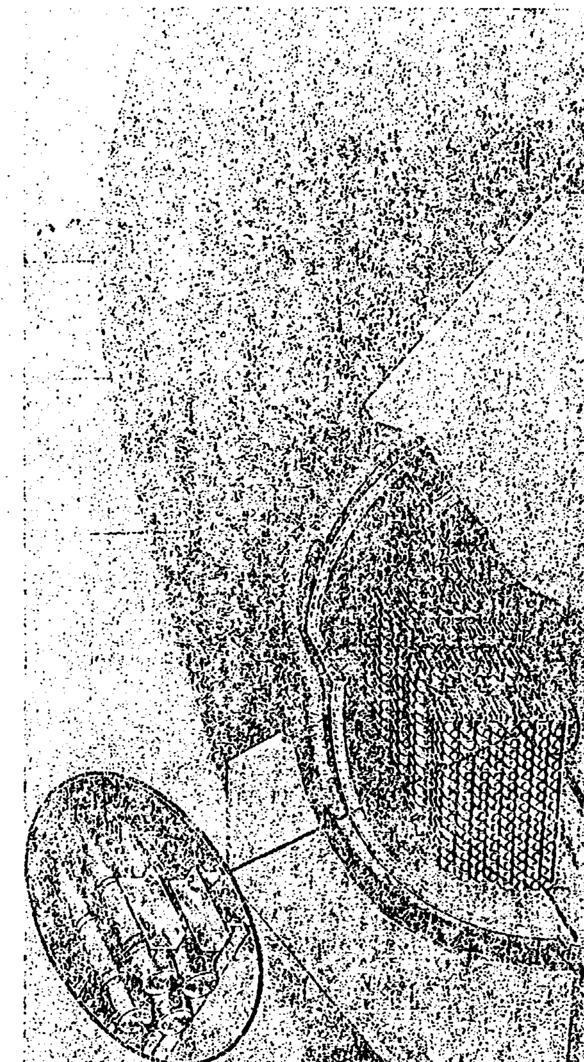
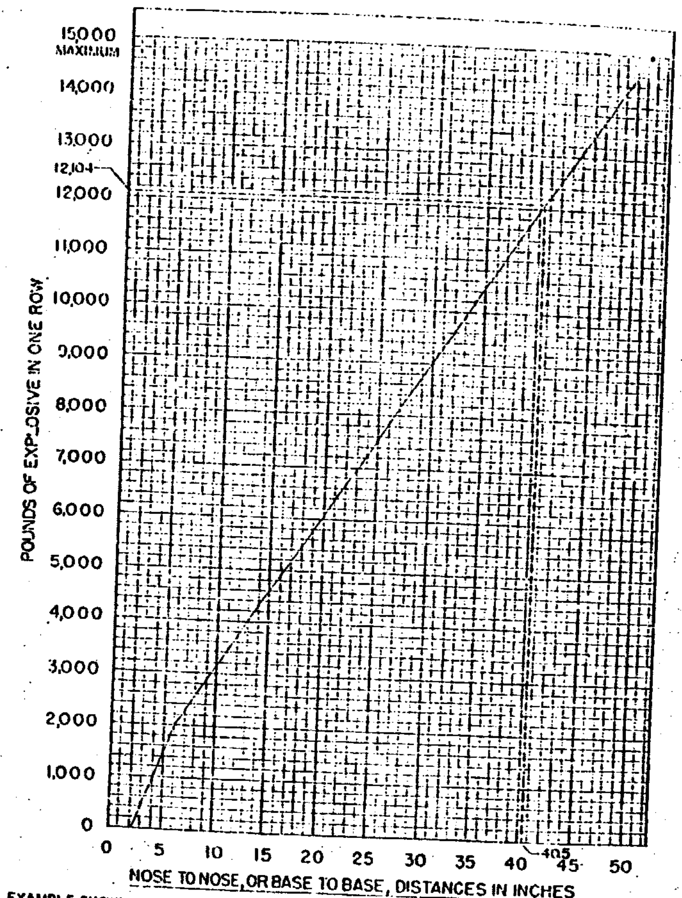


Figure 157 — Method of Stacking Shell in Igloo Magazine Storage



EXAMPLE SHOWN: M107 HE SHELL FOR 155-MM HOW. CONTAINS 15.13 LBS. OF EXPLOSIVE PER SHELL. STORING 80 SHELL, 10 HIGH, OR 800 SHELLS IN ONE ROW IS EQUAL TO 800 X 15.13, OR 12,104 LBS. OF EXPLOSIVE. FROM THE CHART, 12,104 LBS IS EQUIVALENT TO A NOSE TO NOSE, OR BASE TO BASE, DISTANCE OF 40.5 INCHES.

NOTE: THE DISTANCES BETWEEN PILES SHOWN BY THIS CHART ARE INTENDED TO LIMIT EXPLOSIONS TO ONE PILE.

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Figure 158 — Quantity-Distance Chart for Above-ground Magazine Storage of Separate-loading Projectiles

are accustomed to assemble, both within and outside of Government establishments. However, buildings on Government establishments in which people are regularly engaged in operations which require the location of such buildings in the magazine area, may be placed in accordance with intraplant or magazine-to-magazine distances. Land limits or boundaries of military reservations will be considered possible sites of inhabited buildings.

(2) PUBLIC RAILWAY. Any steam, electric, or other railroad which carries passengers for hire.

(3) PUBLIC HIGHWAY. Any street, alley, road, or navigable stream open to the use of the general public.

(4) NAVIGABLE STREAM. A body of water capable of extensive navigation by tugs, barges, or larger vessels.

(5) NEAREST MAGAZINES. The nearest magazines containing explosives or ammunition. The amount of explosives or ammunition permitted to be stored in a magazine can sometimes be increased if the nearest magazines are filled with inert materials, thus greatly increasing the distances to the nearest magazines containing explosives or ammunition.

(6) MAXIMUM PERMITTED. The largest amount of explosives or ammunition permitted to be stored in a magazine even if it is more isolated than the tables prescribe. It is imperative that the loss of military supplies be kept to an absolute minimum.

(7) STRUCTURAL DAMAGE. The serious weakening or displacement of foundations or brick or stone supporting walls or the breaking of wooden main supporting members in outside or inside walls. No readily reparable damage such as broken glass or loosened plaster is considered structural damage.

e. **Explosive content.** The explosive content of ammunition or components is shown in the technical manuals for each caliber and type of gun, on ordnance drawings, and in ORD 11 SNL's; if such information is not available, it should be requested from the Chief of Ordnance. The quantities shown in the following tables were computed as follows:

(1) SMOKELESS POWDER. The quantities in pounds are the net weights of the powder in the boxes or in the propelling charges.

(2) PYROTECHNICS. The quantities are based on the net weight of the illuminant or explosive composition.

(3) SEPARATE-LOADING AND UNFIXED SHELL AND BOMBS. The quantities are computed by taking the net weight of explosive in the charge of one shell and multiplying by the number of shell or bombs in the magazine.

(4) FIXED AMMUNITION. The quantity is the net weight of the high-explosive charge in the shell multiplied by the number of rounds. The smokeless powder propelling charge is so much less hazardous that it is not included in the computation for this class of ammunition.

(5) ROCKETS. The quantity to be considered for quantity-distance purposes is the weight of the high explosive in the head (shell) plus the weight of the propelling charge in the motor. If there is a detonation of the explosive in the head, the propelling charge may be expected to detonate as well. For classification of rocket motors refer to subparagraph f (4).

f. Classes of explosives and ammunition. The grouping of explosives and ammunition into classes listed below does not imply that the items in a particular class are to be stored together but means merely that the hazards involved are similar for all items in the same class. The items which may be stored together on one magazine are set forth in the Combination Storage Chart, paragraph 173. The maximum amount of explosives permitted in any location is the top limit for the distance specified. However, the quantity may be excessive for any particular case under conditions surrounding the individual operations. Therefore, it is mandatory that local limits be established in amount no greater than those consistent with continuous and efficient operation. Operations and personnel will be so arranged consistent with continuous efficiency as to constitute the smallest personnel exposure to any one explosion hazard. When military explosives and ammunition are packed in accordance with the provisions of War Department drawings and specifications, they may be grouped, according to the degree of hazard involved, into the following classes:

(1) CLASS 1. *Small-arm ammunition including 20-mm, except HE and HE-I rounds; mechanical time fuzes without boosters; AT practice grenade; Engineer Corps combination, pull, pressure, and release firing devices; thermit; miner's safety fuse; fuse lighters M1 and M2.* This class is principally a fire hazard. No quantity limit is placed on storage of materials in this class.

(2) CLASS 2. *Single-base multiperforated smokeless powder of web thickness greater than 0.019 inch; chemical ammunition containing phosphorus (except complete rounds); thermite and similar burning compositions; illuminating, flare, or signal compositions which have been consolidated in the final press operations so that no explosive material is exposed; 60-mm and 81-mm mortar illuminating shell.* These materials may become unsafe under extreme conditions of moisture, high temperature, or age. They burn with intense heat, but usually do not form dangerous missiles or generate pressures which will cause serious structural damage to adjacent magazines.

CLASS 2. QUANTITY-DISTANCE TABLE

Smokeless powder in containers (in boxes, powder cans, cartridge storage cases, etc.); pyrotechnics (footnote [1]); chemical ammunition containing phosphorus (except complete rounds); or 60-mm and 81-mm mortar illuminating shell (footnote [4])

QUANTITY (POUNDS)		MINIMUM UNBARRICADED DISTANCE IN FEET (LOCAL NEAREST)			
Over	Not Over	Inhabited Building	Public Railway	Public Highway	Magazine [2]
100	1,000	75	75	75	50
1,000	5,000	115	115	115	75
5,000	10,000	150	150	150	100
10,000	20,000	190	190	190	125
20,000	30,000	215	215	215	145
30,000	40,000	235	235	235	155
40,000	50,000	250	250	250	165
50,000	60,000	260	260	260	175
60,000	70,000	270	270	270	185
70,000	80,000	280	280	280	190
80,000	90,000	295	295	295	195
90,000	100,000	300	300	300	200
100,000	200,000	375	375	375	250
200,000	300,000	450	450	450	300
300,000	400,000	525	525	525	350
400,000	500,000[3]	600	600	600	400
Smokeless powder in bulk (not in containers)					
100	1,000	100	100	100	50
1,000	5,000	150	150	150	75
5,000	10,000	200	200	200	100
10,000	20,000	250	250	250	125
20,000	30,000	285	285	285	145
30,000	40,000	310	310	310	155
40,000	50,000	330	330	330	165
50,000	60,000	345	345	345	175
60,000	70,000	360	360	360	185
70,000	80,000	375	375	375	190
80,000	90,000	390	390	390	195
90,000	100,000	400	400	400	200
100,000	200,000	500	500	500	250
200,000	300,000[3]	600	600	600	300

[1]For storage of Class 2 pyrotechnics and pyrotechnic materials, the following figures apply under the conditions given:

(a) Illuminating, flare or signal compositions which have been consolidated in the final press operations and are so closed that no explosive material is exposed, and military pyrotechnics, except Class 9 materiel, that have been boxed and are ready for shipment, may be stored at one-half of the Class 2 distances.

(b) In quantities from 100 to 500 pounds, inhabited building, public railway, and public highway distances are 50 feet; magazine distance is 35 feet.

(c) Total quantity of pyrotechnic or pyrotechnic materials at any one location should not exceed 50,000 pounds and must not exceed 200,000 pounds.

[2]For storage in standard igloo magazines, prescribed distances may be halved from all sides except the door end.

[3]Maximum quantity permitted at any one location (except pyrotechnics and pyrotechnic materials).

[4]When necessary, 60-mm and 81-mm mortar illuminating shell may be stored with Class 4 items.

(3) CLASS 3. *All loaded fuzes except fuzes containing HE loaded boosters; AT practice mines containing a smoke charge; and artillery primers.* These usually explode progressively, not more than a box or two at a time. Pressures which will cause structural damage to adjacent magazines usually are not generated. Missiles are small and light, and usually fall within 100 yards.

CLASS 3. QUANTITY-DISTANCE TABLE

QUANTITY (POUNDS OF EXPLOSIVE)	MINIMUM UNBARRICADED DISTANCE IN FEET FROM NEAREST[1]			
Not Over	Inhabited Building	Public Railway	Public Highway	Magazine
50	400	400	400	60
200	400	400	400	100
1,000	400	400	400	180
10,000[2]	400	400	400	300

[1]For storage in standard igloo magazines, prescribed distances may be halved from all sides except the door end.

[2]Maximum quantity permitted at any one location.

(4) CLASS 4. *When packed in accordance with ordnance drawings and specifications: Fixed and semifixed artillery ammunition including 20-mm HE-I (complete rounds), with all types of projectiles except pentolite-loaded shell; light mortar ammunition (81-mm and smaller); grenades, including practice grenade Mk 2; antipersonnel mine M2; blank ammunition for cannon; rocket ammunition assembled in complete rounds, except those with HE-loaded heads but including 4.5-inch TNT-loaded rocket T22, and rocket motors (see footnote[3], Class 4 Quantity-Distance Table.* Items in this class usually explode progressively, only a few boxes at a time, and many explosions of individual rounds are of low order. Pressures which will cause structural damage to adjacent magazines usually are not generated. Most missiles will fall within 200 yards. This class includes all fixed and semifixed chemical shell (complete rounds) for artillery except that quantity limitation does not apply. It also includes 76-mm and 3-inch illuminating projectile, complete rounds. Although 60-mm and 81-mm mortar illuminating shell are Class 2 items, they may be stored with Class 4 items when necessary.

(5) CLASS 5. *Separate-loading shell, loaded with explosive D, and all calibers of shell not assembled to or packed with cartridge cases.* These usually explode, one shell at a time and, in nearly all cases, with low order. The missiles are limited as to number and range, and most of them fall within 400 yards.

(6) CLASS 6. *Fuzes containing HE-loaded boosters, adapter-boosters, packed separately in boxes.* These items usually explode progressively by stacks. Structural damage caused by the pressures is usually limited to adjacent magazines. Missiles are light and usually fall within 200 yards.

CLASS 4. QUANTITY-DISTANCE TABLE

QUANTITY (POUNDS OF EXPLOSIVE)	MINIMUM UNBARRICADED DISTANCE IN FEET FROM NEAREST[1]			
Not Over	Inhabited Building	Public Railway	Public Highway	Magazine
50	1,200	1,200	1,200	60
500	1,200	1,300	1,200	140
1,000	1,200	1,200	1,200	180
50,000	1,200	1,200	1,200	225
500,000[2]	1,200	1,700	1,200	300

[1]For storage in standard igloo magazines, prescribed distances may be halved from all sides except the door end.

[2]Maximum quantity permitted at any one location.

[3]Class 4 rockets with motors assembled to loaded or unloaded heads, should not be stored in above-ground magazines located at less than the following missile distances from the listed locations:

LOCATION	MINIMUM MISSILE DISTANCE
Inhabited Building	Maximum flight range of rocket or 4,310 feet, whichever is less
Public Railway	60% of maximum flight range of rocket or 2,590 feet, whichever is less
Public Highway	30% of maximum flight range of rocket or 1,300 feet, whichever is less

CLASS 5. QUANTITY-DISTANCE TABLE

QUANTITY (POUNDS OF EXPLOSIVE)	MINIMUM UNBARRICADED DISTANCE IN FEET FROM NEAREST[1]			
Not Over	Inhabited Building	Public Railway	Public Highway	Magazine
1,000	1,200	1,200	1,200	100
25,000	1,200	1,200	1,200	200
650,000[2]	1,200	1,200	1,200	300

[1]For storage in standard igloo magazines, prescribed distances may be halved from all sides except the door end.

[2]Maximum quantity permitted at any one location.

CLASS 6. QUANTITY-DISTANCE TABLE

QUANTITY[1] (POUNDS OF EXPLOSIVE)	MINIMUM UNBARRICADED DISTANCE IN FEET FROM NEAREST[2]			
Not Over	Inhabited Building	Public Railway	Public Highway	Magazine
50	240	140	70	60
200	240	140	70	100
5,000	1,500	900	450	200
100,000[3]	1,500	900	450	300

[1]When items of this class are stored in concrete igloo magazines, the quantity-distance requirements of Class 9, bulk explosives, will govern, except that no distances less than one-half the distance prescribed in this table for Class 6 items are authorized. The quantity of explosive material given in paragraph 172 e (5) may be used when in above-ground magazines if the material is stacked and segregated in accordance with Ordnance drawings.

[2]For storage in standard igloo magazines, prescribed distances may be halved from all sides except the door end.

[3]Maximum quantity permitted at any one location.

(7) CLASS 7. *Separate-loading HE shell of all calibers, except shell loaded with explosive D.* All in a magazine may explode but the explosion may be limited to one pile by arranging the material in accordance with instructions for piling separate-loading shell given in paragraph 172 e (5). Structural damage usually is limited to adjacent buildings. Most missiles will fall within 500 yards.

CLASS 7. QUANTITY-DISTANCE TABLE

QUANTITY[1] (POUNDS OF EXPLOSIVE)	MINIMUM UNBARRICADED DISTANCE IN FEET FROM NEAREST:			
Not Over	Inhabited Building	Public Railway	Public Highway	Magazine
25,000	1,800	1,800	1,800	200
500,000[3]	1,800	1,800	1,800	300

[1]When items of this class are stored in concrete igloo magazines, the quantity-distance requirements of Class 9, bulk explosives, will govern, except that no distances less than one-half the distance prescribed in this table for Class 7 items are authorized. The quantity considered will be in accordance with paragraph 172 e (5), when stacked and properly segregated in above-ground magazines.

[2]For storage in standard igloo magazines, prescribed distances may be halved from all sides except the door end.

[3]Maximum quantity permitted at any one location. When magazines with maximum capacities substantially less than this quantity are in use or to be installed, reduced distances may be obtained from the Office of the Chief of Ordnance.

(8) CLASS 8. *Primer percussion elements, detonators, primer-detonators for bombs, detonating elements, and blasting caps, packed in accordance with ordnance drawings.* All the contents of a magazine may explode at one time. However, as the total amount of explosives is small and not closely confined, structural damage usually is limited to adjacent magazines. Light missiles of very limited range are formed.

CLASS 8. QUANTITY-DISTANCE TABLE

QUANTITY (POUNDS OF EXPLOSIVE)	MINIMUM UNBARRICADED DISTANCE IN FEET FROM NEAREST[1]			
Not Over	Inhabited Building	Public Railway	Public Highway	Magazine
2,000[2]	980	590	300	300
5,000	1,200	720	360	300
10,000	1,500	900	450	300
15,000	1,610	970	490	300
20,000[3]	1,740	1,040	520	300

[1]For storage in standard igloo magazines, prescribed distances may be halved from all sides except the door end. Distances for above-ground magazines may be reduced one-half by use of barricades.

[2]For quantities less than 2,000 pounds of explosive, distances given in the table for Class 9 and Class 10 explosives may be used.

[3]Maximum quantity permitted at any one location.

(9) CLASS 9. *Bulk priming, initiating, and high explosives; flash-light powder; photoflash composition; demolition blocks; "primacord" detonating cord; spotting charges; black powder; dynamite; Mk 3-series offensive hand grenades; loose pyrotechnic materials before final consolidation, except thermate and other slow burning incendiary compounds (footnote[1] Class 9 Quantity-Distance Table); EC blank fire powder containing less than 30 percent water; quickmatch; double-base smokeless powder, and single-base smokeless powder with web thickness less than 0.019 inch.* Explosives in this group include lead azide, mercury fulminate, PETN, pentolite, tetrytol, RDX, Composition A, Composition B, Composition B-2, Composition C, Composition C-2, torpex, and mixtures of magnesium and black powder. If more than 2,500 pounds of lead azide, mercury fulminate, or PETN are to be stored in a single magazine, special permission must be obtained from the office of the Chief of Ordnance. In a fire, black powder burns with explosive rapidity; high explosives may burn or explode depending upon the material, quantity, and degree of confinement.

(10) CLASS 10. *Demolition, fragmentation, and photoflash bombs; bombs loaded with Comp. B and tritonal; bangalore torpedoes; torpedo warheads; HE antitank mines; antipersonnel mines M3; HE-loaded AT grenades; HE 4.2-inch mortar shell; Livens HE shell bursters for chemical shell or bombs; auxiliary boosters; HE mortar ammunition (larger than 81-mm); HE rocket shell with or without motors assembled thereto, except 4.5-inch TNT-loaded rocket T22, and fixed and semifixed artillery ammunition containing pentolite, assembled as complete rounds (footnote[3], Classes 9 and 10 Quantity-Distance Table).* All the contents of a magazine may explode at one time. If this happens, structural damage caused by the pressure generated is not likely to occur at the distance given in the table. Most missiles will fall well within these distances. When fragmentation bombs are concerned, distances specified in Classes 9 and 10 table will not be less than the distances as stated in the Class 4 Quantity-Distance Table, but may be one-half the distance as stated in the Class 4 table when stored in concrete igloo magazines, except from the door end.

(11) CLASS 11. *Chemical ammunition except complete rounds and that containing white phosphorus.* Chemical shell, bombs, and grenades stored and issued by the Ordnance Department are not

CLASSES 9 AND 10. QUANTITY-DISTANCE TABLE

QUANTITY[1] (POUNDS OF EXPLOSIVE)		MINIMUM UNBARRICADED DISTANCE IN FEET FROM NEAREST[2,4]			
Over	Not Over	Inhabited Building	Public Railway	Public Highway	Magazine
...	10	145	90	45	60
10	25	145	90	45	60
25	50	145	90	45	60
50	100	240	140	70	80
100	200	390	230	110	100
200	300	520	310	150	120
300	400	640	380	190	130
400	500	720	430	220	140
500	600	800	480	240	150
600	700	860	520	260	158
700	800	920	550	280	165
800	900	980	590	300	170
900	1,000	1,020	610	310	180
1,000	1,500	1,120	670	330	210
1,500	2,000	1,200	720	360	230
2,000	3,000	1,320	790	390	260
3,000	4,000	1,420	850	420	280
4,000	5,000	1,500	900	450	300
5,000	6,000	1,560	940	470	300
6,000	7,000	1,610	970	490	300
7,000	8,000	1,660	1,000	500	300
8,000	9,000	1,700	1,020	510	300
9,000	10,000	1,740	1,040	520	300
10,000	15,000	1,890	1,130	560	300
15,000	20,000	2,010	1,200	600	300
20,000	25,000	2,180	1,310	650	300
25,000	30,000	2,320	1,390	690	300
30,000	35,000	2,450	1,470	730	300
35,000	40,000	2,570	1,540	770	300
40,000	45,000	2,690	1,610	800	300
45,000	50,000	2,810	1,680	840	300
50,000	55,000	2,920	1,750	880	400
55,000	60,000	3,030	1,820	910	400
60,000	65,000	3,130	1,880	940	400
65,000	70,000	3,220	1,930	970	400
70,000	75,000	3,310	1,990	1,000	400
75,000	80,000	3,390	2,040	1,020	400
80,000	85,000	3,460	2,080	1,040	400
85,000	90,000	3,520	2,120	1,060	400
90,000	95,000	3,580	2,150	1,080	400
95,000	100,000	3,630	2,180	1,090	400
100,000	125,000	3,750	2,250	1,120	800
125,000	150,000	3,870	2,320	1,160	800
150,000	175,000	3,980	2,390	1,190	800
175,000	200,000	4,090	2,450	1,220	800
200,000	225,000	4,200	2,520	1,260	300
225,000	250,000[3]	4,310	2,590	1,300	800

[1]For storage of Class 9 and 10 pyrotechnics or pyrotechnic materials, the total quantity of hazardous material at any one location should not exceed 50,000 pounds and must not exceed 200,000 pounds.

[2]For storage in standard igloo magazines, prescribed distances may be halved from all sides except the door end. Distances in above-ground magazines may be reduced to one-half by use of barricades.

[3]Maximum permitted at any one location.

[4]If rockets with motors assembled to shell not filled with high explosive are stored in above-ground magazines, the magazines should be separated from each other by Class 4 distances. TNT-loaded rockets with loaded motors assembled to shell are designated Class 10 ammuni-

considered to be an explosive hazard, and no limit has been placed on this type of ammunition as far as quantity-distance limits are concerned. However, storage must comply with the requirements of paragraph 174 and the Combination Storage Chart, paragraph 173.

(12) CLASS 12. *Explosives such as ammonium nitrate, DNT, and wet nitrocellulose.* These materials are insensitive and can be detonated only by very strong initiation. When stored in an explosives area where there is a possibility that explosives may be projected into them, they will be stored in accordance with the regulations for Class 9 explosives. When stored in an area of fire hazards only and separated by inhabited-building distences from areas containing explosives or ammunition, these materials may be stored in accordance with the regulations for smokeless powder (see Class 2 Quantity-Distance Table).

g. Quantity-Distance table for hillside magazines. This table applies to magazines so constructed that they are covered by earth at least to the highest point reached by explosives stored within them, and separated from each other by continuous ground in such manner that the level of the separating material does not fall below the line joining the highest points reached by explosives stored within adjacent magazines.

QUANTITY OF HIGH EXPOSIVES (In pounds up to)	DISTANCE (In feet)
20,000	100
30,000	110
40,000	120
50,000	130
60,000	135
70,000	140
80,000	145
90,000	150
100,000	155
125,000	165
150,000	175
175,000	185
200,000	190
250,000	200

tion. The missile distance in the table below should be observed for all rockets with loaded motors attached to loaded or unloaded shell when stored in above-ground magazines.

LOCATION	MINIMUM MISSILE DISTANCE
Inhabited Building	Maximum flight range of rocket or 4,310 feet, whichever is less
Public Railway	60% of maximum flight range of rocket or 2,590 feet, whichever is less
Public Highway	30% of maximum flight range of rocket or 1,300 feet, whichever is less

[5]For storage of fixed and semifixed artillery ammunition containing pentolite, Class 9 and 10 quantity-distances apply except that distances less than those applicable to Class 4 ammunition are not authorized.

h. **Intraplant quantity-distance table.**

Quantity of explosives[1] in separate building or within substantial dividing walls (in pounds)		Minimum unbarricaded distance between (in feet)
Over	Not over	
---	10	---
10	25	40
25	50	60
50	100	80
100	200	100
200	300	120
300	400	130
400	500	140
500	750	160
750	1,000	180
1,000	1,500	210
1,500	2,000	230
2,000	3,000	260
3,000	4,000	280
4,000	5,000	300
5,000	6,000	320
6,000	7,000	340
7,000	8,000	360
8,000	9,000	380
9,000	10,000	400
10,000	12,500	420
12,500	15,000	450
15,000	17,500	470
17,500	20,000	490
20,000	25,000	530
25,000	30,000	560
30,000	35,000	590
35,000	40,000	620
40,000	45,000	640
45,000	50,000	660
50,000	55,000	680
55,000	60,000	700
60,000	65,000	720
65,000	70,000	740
70,000	75,000	770
75,000	80,000	780
80,000	85,000	790
85,000	90,000	800
90,000	95,000	820
95,000	100,000	830
100,000	125,000	900
125,000	150,000	950
150,000	175,000	1,000
175,000	200,000	1,050
200,000	225,000	1,100
225,000	250,000	1,150

[1]Applies to high explosives or items loaded with high explosives.

173. COMBINATION (MIXED) STORAGE OF AMMUNITION AND EXPLOSIVES AT POSTS, CAMPS, AND STATIONS.

a. The following table and chart show the ammunition and explosives which may be stored together at posts, camps, and stations. All items in a group may be stored together. Where an "X" appears at the intersection of a horizontal row and a vertical column all items in the two groups may be stored together. Where an "O" appears at the intersections of a horizontal row and a vertical column all items in those two groups may be stored together if the total explosives content of the items of the two groups stored together in one magazine or revetment does not exceed 1000 pounds.

b. Mixed storage as permitted by this table and chart does not authorize violation of the quantity-distance tables for the storage of ammunition and explosives at posts, camps, and stations. Where two or more quantity-distance classes of ammunition and explosives are stored together in a magazine or revetment the intermagazine distance and safety distances to inhabited buildings, public railways, and public highways shall be those specified for the most hazardous class of material stored therein.

c. *Groups.* Ammunition and explosives are classified into groups as follows and shown in the Combination Storage Chart below:

I. CARTRIDGES FOR SMALL ARMS AND OTHER SIMILAR CARTRIDGES EXCEPT THOSE WITH EXPLOSIVE BULLETS: Included are ball, tracer, armor-piercing, incendiary, armor-piercing-incendiary, blank, frangible, gallery practice, guard, high-pressure test, and subcaliber cartridges, calibers .22 to .60 inclusive; 20-mm cartridges, armor-piercing, ball, and practice; shotgun cartridges; grenade propelling cartridges, trench and field mortars ignition cartridges, blank cartridges for miniature bombs, and cartridges for bomb cluster adapters, when stored separately from the complete rounds of which they are components; and cartridges packed with grenade-projection adapters.

II. MILITARY PYROTECHNICS: Included are all types of aircraft and ground signals, flares, and lights.

III. SMOKE AMMUNITION EXCEPT THAT LOADED WITH WP: Included are all fixed, semifixed, and separate-loading shell, mortar shell, grenades, rockets, bombs, smoke pots, and drums, and containers filled with HC, FS, FM, and colored smoke mixtures.

IV. INCENDIARY AMMUNITION: Included are bombs, grenades, and rockets.

COMBINATION STORAGE CHART[1, 2]

GROUPS	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII
I. Cartridges for small arms and other similar cartridges	X	X	O	O	O	O	O	X	X	X	X	X	O	O	O	O	O	O
II. Military pyrotechnics	X	X																
III. Smoke ammunition, except WP	O		X	X	O	O												
IV. Incendiary bombs, grenades and rockets	O		X	X	O	O												
V. WP ammunition	O		O	O	X	O												
VI. Chemical ammunition	O		O	O	O	X												
VII. Separate-loading propelling charges and bulk powder	O						X											
VIII. Fuzes, primers, bursters, boosters, etc.	X							X										
IX. Fixed and semifixed ammunition except gas and smoke	X								X	X	O	O						
X. Mortar ammunition and grenades except gas and smoke	X								X	X	O	O						
XI. Rockets, except gas and smoke	X								O	O	X	O						
XII. Land mines, mortar ammunition and fragmentation bombs	X								O	O	O	X						
XIII. Separate-loading projectiles	O												X					
XIV. Bombs, depth charges, aerial mines except gas and smoke	O													X				
XV. Demolition materials	O														X	O	O	O
XVI. Dynamite	O														O	X	O	O
XVII. Black powder ammunition and bulk black powder	O														O	O	X	O
XVIII. Photoflash bombs	O														O	O	O	X

[1] An "X" at the intersection of a horizontal row and a vertical column denotes that all items in the two groups may be stored together.
[2] An "O" at the intersection of a horizontal row and a vertical column denotes that all items in the two groups may be stored together if the explosive content of the items of the two groups stored together in one magazine or revetment does not exceed 1000 pounds.

V. WP AMMUNITION: Included are fixed, semifixed, and separate-loading shell, mortar shell, grenades, rockets, and bombs, loaded with white phosphorus.

VI. CHEMICAL AMMUNITION: Included are fixed, semifixed, and separate-loading shell, mortar shell, grenades, rockets, and bombs, loaded with H, L, CG, PS, CNS, CNB, AC, CC, A-1, A-2, CK, E-1, P-1, CN, CN-DM, DM, NC, and CI chemical compositions.

VII. SEPARATE-LOADING PROPELLING CHARGES AND BULK PROPELLENT POWDERS: Included are propelling charges for calibers 4.5-inch to 16-inch inclusive, bulk propellent powders of all classes, mortar increments, and other propelling charges, when packed separately from the complete rounds or complete charges of which they are a component.

VIII. FUZES, PRIMERS, BOOSTERS, AND BURSTERS: Included are adapters, adapter-boosters, fuzes (all types), primers, primer-detonators, detonators, blasting caps, percussion caps, destructors, and bursters.

IX. FIXED AND SEMIFIXED AMMUNITION, EXCEPT SMOKE, INCENDIARY, WP, AND CHEMICAL: Included are high-explosive, high-explosive-antitank, shot, armor-piercing, practice, canister, shrapnel, and illuminating ammunition for calibers 37-mm to 120-mm; high-explosive, incendiary, and high-explosive-incendiary, 20-mm ammunition; all cartridges for 40-mm and 57-mm guns, and cartridges for small arms with explosive bullets.

X. MORTAR AMMUNITION UP TO AND INCLUDING 81-MM (3-INCH) AND HAND AND RIFLE GRENADES EXCEPT SMOKE, INCENDIARY, WP, AND CHEMICAL: Included are high-explosive, illuminating, and practice ammunition; antitank, offensive, fragmentation, and practice hand and rifle grenades; and grenade kits.

XI. ROCKETS, EXCEPT SMOKE, INCENDIARY, WP, AND CHEMICAL: Included are high-explosive, high-explosive-antitank, illuminating, target, and practice rockets; motors and all loaded components for rockets.

XII. LAND MINES, FRAGMENTATION BOMBS (FUZED), AND MORTAR SHELL 105-MM AND LARGER, EXCEPT SMOKE, INCENDIARY, WP, AND CHEMICAL: Included are antitank, antipersonnel, and practice mines (with fuzes); fragmentation bombs (fuzed); bomb clusters, high-explosive and practice; and high-explosive and practice mortar shell.

XIII. SEPARATE-LOADING PROJECTILES, EXCEPT WP, SMOKE AND CHEMICAL: Included are high-explosive, armor-piercing, deck-piercing, and illuminating shell, and shrapnel for calibers 4.5-inch to 16-inch, inclusive.

XIV. BOMBS, DEPTH CHARGES, AERIAL MINES AND AERIAL TORPEDOES EXCEPT SMOKE, INCENDIARY, WP, AND CHEMICAL: Included are demolition, general purpose, armor-piercing, semi-armor-piercing, high capacity, light case, and leaflet bombs; depth charges; aerial mines; and aerial torpedoes.

XV. DEMOLITION MATERIALS AND BULK EXPLOSIVES: Included are bulk TNT, bulk explosive "D," plastic explosives, demolition blocks, nitrostarch, cratering explosives, bangalore torpedoes, shaped charges, snake charges, primacord and cordeau detonant.

XVI. DYNAMITE, ALL TYPES.

XVII. BLANK AMMUNITION FOR CANNON, SPOTTING CHARGES, SMOKE PUFF CHARGES, BULK BLACK POWDER: Included are all components loaded with black powder (except fuzes) packed separately from the complete rounds of which they are components; and all fireworks including simulated grenades, dago bombs, firecrackers, etc.

XVIII. PHOTOFLASH BOMBS AND PHOTOFLASH POWDER.

174. STORAGE OF SPECIFIC TYPES.

a. **Black powder.** Black powder in bulk, saluting, practice-bomb, and smoke-puff charges should be stored in dry and, if practicable, bulletproof magazines. Black powder will never be handled or stored in a barracks, general supply room, inhabited building, or any building heated by stoves or open fires. In a magazine containing black powder, explosives-operations safety (nonsparking) shoes will be worn, and no work will be done other than that involved in the actual storage and removal of the powder from the containers and the removal of spilled grains. The floor of the building in which such operations as repacking of black powder is performed should be covered with a tarpaulin or canvas. Black powder does not deteriorate in storage if kept dry. Containers of saluting, practice, and smoke-puff charges are stored with tops up. Containers of black powder should be carefully examined at the time of receipt for weak spots and holes, with special attention to examination for small holes, such as nail punctures, which are not immediately evident. Damaged containers are not repaired; their contents are transferred to serviceable drums. Condensed moisture may rust the container or corrode the cap. When containers are painted, caps replaced, or contents transferred, the following conditions must prevail:

(1) The work will be done at least 100 feet from any magazine containing explosives or ammunition.

(2) If any powder is spilled, work will stop until the spillage is carefully taken up and the spot washed with water. The powder taken up will be destroyed by dumping in water.

(3) If tools are required to open a container, only safety tools will be used, and the operator will be protected by a barricade and the work will be done in strict compliance with instructions issued for this purpose by the Chief of Ordnance.

(4) The quantity of powder in the vicinity of operations will be kept to a minimum.

(5) Special care will be observed to see that all information marked on the original container is reproduced when repainting the old container or transferring the contents to a new container.

(6) Empty black powder containers will be thoroughly washed out with water.

b. **High explosives—TNT, explosive D, tetryl, triton blocks.** These are stable in storage and require only protection from moisture and, if practicable, from rifle bullets. They are stored in wax paper-lined wooden boxes. In handling loose explosives of this class, explosives-operations safety (nonsparking) shoes should be worn. Nonsparking tools should be used in opening boxes. Broken containers may be repaired or contents transferred only at a distance of 100 feet from a magazine containing explosives or ammunition.

c. **Dynamite.** Dynamite is sensitive to heat and shock. It should be stored in fireproof, bulletproof magazines. Nonsparking tools will be used in opening cases. Empty containers that have been used for dynamite will be destroyed by burning. Oily stains of nitroglycerin will be scrubbed up with a solution consisting of ½ gallon of water, ½ gallon of wood alcohol, and 2 pounds of sodium sulfite or potassium sulfite. Store cases of dynamite initially right side up, so cartridges will lie flat. However, in order to eliminate the possibility of exudation of nitroglycerin from the cartridges, it will be necessary to turn the cases, based on average storage temperatures, in accordance with the following:

Average Storage Temperature	Interval Between Turnings
Below 30° F	Do not turn
30 to 60° F	Six weeks
60 to 75° F	One month
Over 75° F	Two weeks

The first turning will result in the cases being bottom side up, with the cartridges still in a horizontal position. Frozen dynamite will not be turned. Where definite knowledge as to the composition of the dynamite is available, straight ammonium nitrate dynamites need not be turned.

d. **Bulk smokeless powder and separate-loading propelling charges.**

(1) These should be stored insofar as practicable in magazines which are well-ventilated and dry. Since smokeless powder is principally a fire hazard, a well-ventilated frame structure covered with corrugated sheet asbestos and built on well-drained ground may be used. Such buildings are often more easily kept dry than fireproof magazines. Bulk smokeless powder is packed in all steel or in metal-lined wooden boxes, which are stored on their sides with dunnage enough to insure free circulation of air through all parts of the pile.

(2) The method of storing propelling charges in fiber or metal containers and bulk powder in boxes is shown on ordnance drawings. When containers of charges 10 inches in caliber and over are stored on their sides, provision must be made to prevent the weight of the upper layers crushing the containers in the lower.

(3) Boxes, crates, bundles, and containers should be stored so that the covers can be readily inspected or removed and so that the containers may be airtested in storage.

(4) Magazines in which smokeless powder is stored should be equipped with a maximum-minimum thermometer which should be read daily or as often as necessary. If the temperature exceeds 100° F for 24 hours or 85° F for 72 hours, the magazine should be cooled by wetting down the exterior with water or by opening the doors and ventilators at *night* and closing them in the *morning.* If this fails to reduce the temperature, the Commanding Officer will decide whether the stores are to be removed to another magazine. When magazines are cooled by such ventilation at night, effective measures will be taken to protect against fire and to close the doors in case of rain.

(5) Smokeless powder, in bulk or in separate-loading charges, is always packed in airtight containers. It is important that such containers remain airtight until the powder is used. When a shipment is received, every container is given a visual inspection to see that it is not damaged and that the cover is in good condition and tight.

(6) Metal containers for propelling charges are fitted with a test hole and plug in the cover so that they can be tested for airtightness after the containers have been opened and closed. Every container in which a propelling charge is stored will be airtested when received and whenever it is subject to handling that might cause it to leak. The testing should be done with a testing set similar to the cartridge-storage-case testing set M1, 24-12-2. However, a motor-driven air compressor will not be taken into a magazine in which explosives or ammunition are stored. If the compressor is driven by a gasoline motor, the motor should be placed no closer than 75 feet to the magazine or any explosive material. A pressure of 3 to 5 pounds is

used and if no drop in pressure is observed in one minute it may be assumed the case is not leaking.

(7) The normal odor in a smokeless powder magazine is a faint odor of alcohol-ether. If this odor is strong, it probably indicates a leaky container. Every leaking container will be repaired or the contents transferred to an airtight container. If the contents of any container show evidence of dampness or moisture, it should be segregated and reported to the Service Command or department ordnance officer. Leaks due to covers or gaskets may be repaired without removing the charge from the container or the container from the magazine, provided care is taken to guard against sparks. Repair of leaks in other parts of the container will be undertaken only after the removal of the charge from the container and the container from the magazine.

(8) Personnel engaged in air testing must become familiar with the odor and appearance of decomposing powder. They should examine each container opened for air test for the characteristic odor. One of the first evidences of dangerous deterioration is the presence of the acid odor of nitrous fumes in place of the normally present odor of alcohol-ether. The odor of decomposing powder is so characteristic that it should not be mistaken.

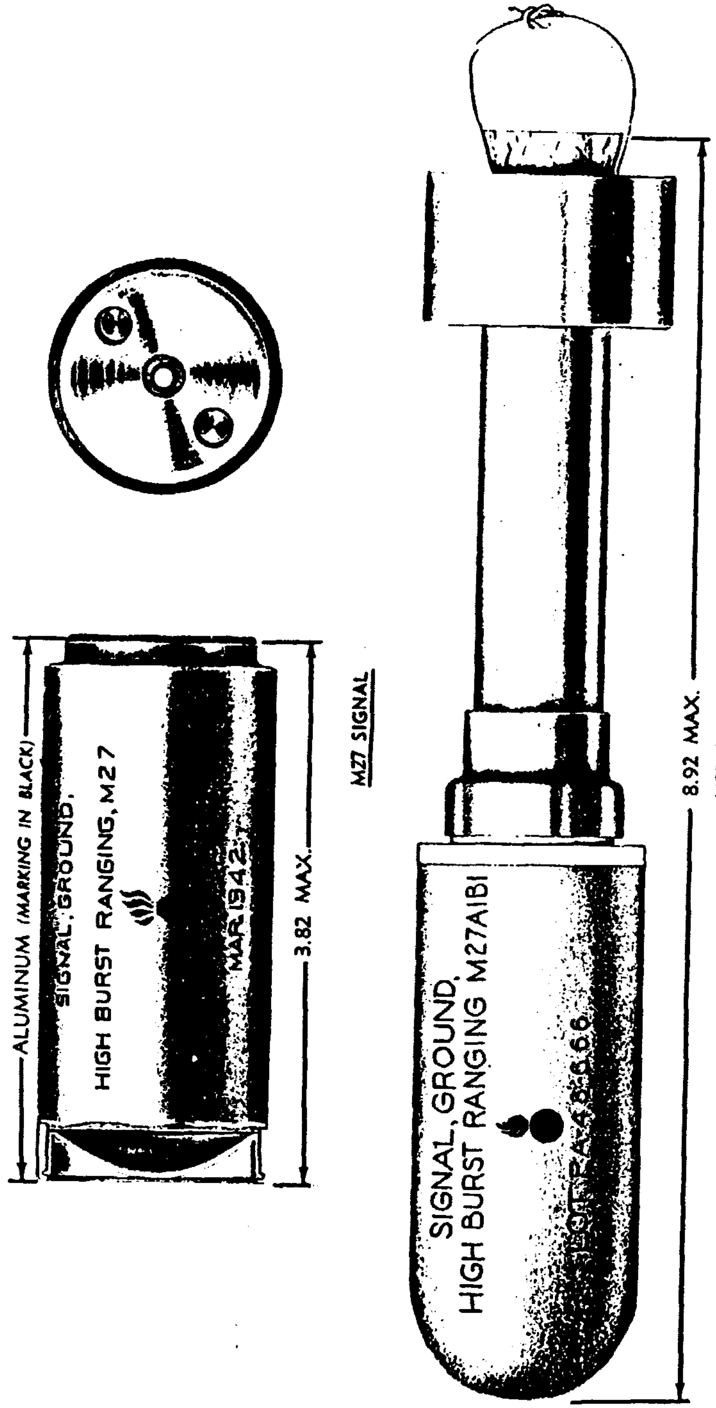
(9) Fiber containers of separate-loading propelling charges are not usually opened unless they are damaged; then the charge is transferred to a serviceable metal container. Fiber containers are not repaired.

(10) Metal containers may rust. They may be repainted but must be removed from the magazine to do so. Care must be taken *to reproduce faithfully the original markings* whenever containers are repainted or changed.

(11) Some fine-grain smokeless powders are almost as sensitive as black powder and equal precautions should be observed. The principal safety measure in regard to smokeless powder, however, is the careful watch for deterioration.

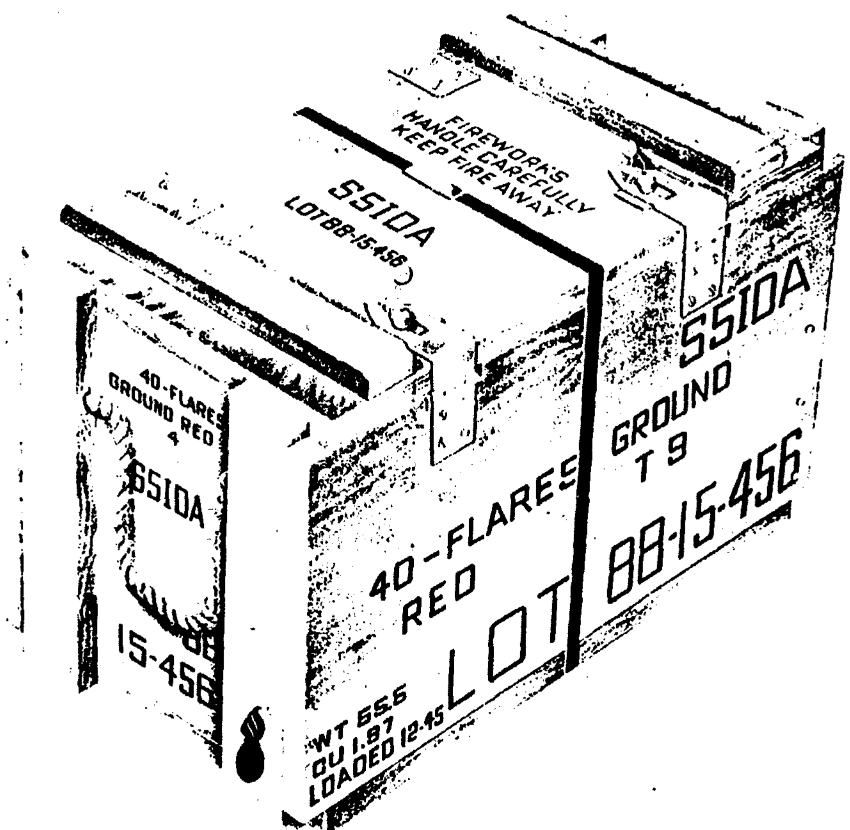
e. **Small-arms ammunition.**

(1) Small-arms ammunition may be stored in any magazine or warehouse which offers good protection against the weather. When magazine space is limited, it may be stored in a general warehouse by partitioning or screening off a section for its exclusive use. This refers to small-arms ammunition only and not to other types with which it may be stored in a magazine. Good protection against moisture and high temperature should be provided. Free ventilation *of all parts of the pile should be insured,* dunnage being used where necessary. Skylights and windows near piles should be shaded so that ammunition will not be exposed to direct sunlight. Care should be taken to avoid piling ammunition near steam pipes. Small-arms am-



RA PD 104838

Figure 119 — High-burst-ranging Ground Signals



RA PD 104839

Figure 120 — Packing Box for Ground Flares

float, nose down, in the water and emit smoke and flame from a hole in the tail for as long as 17 minutes, serving as a reference point for air navigation at night.

128. SLICK MARKER. This item (fig. 115), is used to produce a persistent slick for reference points on the water. It contains a fluorescent dye in a paper composition case which shatters upon impact with the water and forms a slick which may be visible for 10 miles at 3,000 feet altitude.

129. SMOKE GRENADES. Both white and colored smoke grenades may be used for signaling. (See chapter 2, section II.)

130. GROUND TYPE FLARES.

a. Airport flares are used on the ground to provide illumination for airplane landings at emergency fields or in case of power failure at airports.

munition packed in boxes fitted with airtight metal liners should not have these liners opened until the ammunition is about to be used. When only a part of a box is used the remaining ammunition in the box should be protected against unauthorized handling and use by firmly fastening the cover in place. Serviceable ammunition turned in by troops should not be stored in open boxes. It should be repacked for storing and reissued at the first opportunity, provided it can be identified by lot number. If it cannot be identified by lot, it automatically becomes grade 3 with certain exceptions and should be disposed of in accordance with directions in WD SB 9-AMM 4.

(2) Tracer and shotgun ammunition should always be stored under the best cover available, preferably in a building providing protection against dampness and having adequate ventilation.

f. **Fixed and semifixed ammunition, grenades, antipersonnel mines, and mortar shell.**

(1) These may be stored in any magazine with good protection from the weather but preferably in fireproof or fire-resistant magazines to reduce to a minimum the danger of fire or explosion. Most of the standard boxes and bundles in which this type of ammunition is packed are provided with cleats and those that are not may be piled with dunnage to insure free circulation of air. Except small-arms ammunition, fixed ammunition is usually packed in individual fiber containers which are then packed in bundles of three containers. If the ammunition is not removed from these sealed containers until it is used, it should remain in good condition. Serviceable rounds which have been removed from their containers, such as those turned in by troops, should be placed in containers which should then be sealed with friction tape and shellac before they are again placed in storage. This procedure will protect the round against deterioration and the primer against accidental blows.

(2) Assembly of fuzes to unfuzed items is forbidden within 100 feet of a magazine containing explosives or ammunition.

(3) It is sound policy to mix quantities of different sizes and types in each of several magazines rather than to store only one kind in each magazine. For example, there may be on hand a sufficient quantity of 75-mm high-explosive rounds to fill one magazine and enough 75-mm armor-piercing rounds for another. Rather than store all high-explosive rounds in one magazine and all armor-piercing rounds in another, it is better storage practice to store half of each type in each magazine. Thus, in case of accident to one magazine, there is still a supply of both types of ammunition on hand.

g. **Separate-loading shell.**

(1) Separate-loading and unfixed shell should be stored in fireproof magazines containing a minimum of inflammable materials. Iron or steel dunnage is preferred to wood and it should be connected

by electrical conductors and grounded. If it is necessary to use wood for dunnage, the amount should be kept to an absolute minimum. Unfuzed shell should be fitted with an iron or steel fuze hole plug. If it is necessary to roll fuzed shell, it should be done carefully and slowly in order to avoid the risk of arming the fuze.

(2) In order to confine an explosion to one stack of shell in above-ground magazine storage, the following precautions will be observed:

(a) Shell should be stored in single stacks, nose to nose and base to base (fig. 156). Shell up to and including 10 inches in diameter should be stacked in accordance with figure 156, and distances specified should be maintained if the shell are loaded with TNT or amatol. If the shell are loaded with explosive D, the distance need be only large enough to permit inspection of the shell and of the fuze cavities.

1. In igloo-type magazines, shell stored in double stacks, base-to-base in contact, with an inspection aisle between noses (fig. 125.1).

(b) The nose-to-nose and base-to-base distances between rows should be equal.

(c) The nose-to-nose distances for each caliber shell (fig. 158 and ordnance drawings) should be strictly observed and the number of shell in each stack should be kept at a minimum consistent with the storage space available.

(3) Shell over 10 inches in diameter may be stored on their sides or on their bases. When stored on their bases, there should be a 1-inch board between the shell and the floor to protect the shell from moisture; shell loaded with explosive D may be stored in intimate contact but shell loaded with TNT should be separated by a distance equal to the caliber of the shell.

(4) The rotating bands on all projectiles should be carefully protected by grommets or some other effective means. Dents or cuts in the band may cause the shell to function improperly in the gun.

h. **Bombs.** GP and SAP bombs have comparatively thin walls and are one of the most hazardous types of ammunition to store because of their tendency to detonate in mass if a fire occurs in, or a heated fragment be projected into, the magazine in which they are stored. Safety can be obtained only by reducing the possibility of fire to the absolute minimum. Bombs should be stored in a fireproof magazine with iron or steel dunnage. If wood must be used for dunnage, the amount should be kept to a minimum. Steel dunnage should be connected by electrical connectors and grounded. A ground system separate from the lightning protective system of the magazine should be provided. Bombs not intended for immediate shipment should be stored as above. Fuzes or primer-detonators should be stored in a separate magazine. All bombs should be stacked so that the fuze cavity can be easily inspected. Fragmentation bombs are stored in the same manner as GP and SAP bombs.

i. **Fuzes, primers, primer-detonators, detonators, and boosters.** These components are usually packed in hermetically sealed containers and boxes. Care should be taken in packing to see that they are properly supported in racks or trays and protected against shock or rough handling. Even when properly packed, this class of components should be handled with great care. Partly filled boxes should be kept securely closed. Magazines for the storage of fuzes should be small to limit the loss of this type of material, and the quantity of fuzes, primers, etc., stored in any one magazine should be kept to a minimum, consistent with the storage space available. Storage of all on hand of any one type in a single magazine is to be avoided if possible.

j. **Pyrotechnics.** Pyrotechnics require protection against moisture, dampness, and high temperature. Dry, well-ventilated magazines of approved fire-retardant construction shall be used for storage. Maximum and minimum thermometers will be placed in representative magazines in which pyrotechnics are stored. In general, the magazines should not be provided with heat. Except those used solely for storage of Class 1 material or finished boxed pyrotechnic ammunition, magazines should not be provided with interior illumination other than through use of portable safety battery lamps. Pyrotechnic material that has been wet is hazardous to store, consequently any boxes that show signs of dampness will be opened and if the pyrotechnic material is wet, it should be destroyed (chap. 4). Pyrotechnics should be handled with care even when properly packed. Certain kinds of this material deteriorate with age and have an expiration date on the containers. Care should be taken to observe the direction for disposal of this material at the time indicated.

k. **Chemical ammunition.**

(1) Chemical ammunition should not be stored with other classes, principally because of the difficulty and danger encountered in fighting a fire involving chemical materials. All munitions containing chemical agents are stored in such a manner that each item is accessible for inspection and may be easily removed from storage in case it should develop a leak. This type of ammunition must be inspected for leaks once a month. Any leaking container should be removed downwind to await disposal.

(2) Whenever a magazine containing chemical ammunition is opened, a responsible officer or foreman should be present to detect the odor of escaping gas. If such an odor is present, all persons entering the magazine will wear the protective devices proper for

the group, all windows and doors of the magazine will be opened, and the leaking container sought out and removed.

(3) Each type of chemical ammunition is preferably stored alone, but may be stored with other chemicals within the same storage group. The special equipment, as listed for each group of chemical agents, should be available in the vicinity, but not in the magazine. The chemical agents are grouped as follows:

(a) Group A: persistent blister casualty gases, H, L, ED, and PS. Magazines for this group should have surface-hardened concrete floors. Special equipment should include gas mask, protective suit, boots, and gloves for each officer, man, or fireman whose duties require his presence in the magazine; chloride of lime; kerosene and flannel cloths; sodium bicarbonate; boric acid; soap; and ample washing facilities.

(b) Group B: harassing and nonpersistent casualty gases and smoke-producing chemical munitions, except WP. Magazines should have surface-hardened concrete floors and free ventilation. Special equipment should include gas masks, gloves, saturated solution of sodium sulfite, saturated alcoholic solution of sodium hydroxide, litters, and wool blankets. Masks will be carried at all times by personnel in the magazine.

(c) Group C: spontaneously inflammable munition, phosphorus (WP). This type magazine should have concrete floors with elevated sills to permit flooding. Special equipment includes tubs or barrels filled with water and large enough to contain the largest component stored. In addition, there should be available rubber gloves and boots, sponges, pails, and copper sulfate solution. Where temperature cannot be controlled in storage, special care must be taken in the storing of shell containing white phosphorus. White phosphorus will melt at temperatures above 105° F. Upon cooling and solidification of the white phosphorus, a void is formed in the top of the shell filler (in the base if the shell is stored nose down; on the side, if stored on the side) adversely affecting ballistics upon use. Where temperature cannot be maintained below the melting point, storage should be arranged so that the ammunition is stored on its base, even if this requires rearranging rounds within their packing. Where this is impracticable, the ammunition should be stored on its side.

(d) Group D: incendiary and readily inflammable substances, TH, FS, HC, CN, CN-DM grenades. No water is to be used in this magazine. No special precautions are necessary except to keep water and fire away, and to remove leaking containers to prevent an accumulation of loose material in the magazine.

(4) Munitions from two or more groups will not be stored together without the specific approval of the Chief of Ordnance.

l. Rockets.

(1) Rockets should be stored in a dry, cool place, and never in the direct rays of the sun. They should not be stored where temperatures exceed 120° F unless otherwise specified on the packing container. Rocket ammunition which is stored with motor assembled to the shell should be given special attention for safety. Rough handling must be avoided as the missile range of rockets greatly extends danger area in event of accident over that of ordinary fixed ammunition. Storage should be with nose down when possible, or if not possible, with all rockets in a single magazine pointed in the same direction. In above-ground magazines, the direction selected for positioning rockets should offer the least damage to personnel and property in case of accidental ignition; in igloos, rockets shall not point toward door ends. Storage in above-ground magazines should be avoided whenever practicable.

(2) Since rocket propelling charges are ignited by electrical means, care must be taken to protect rockets from being ignited by stray electrical currents such as might arise from contact with extension cords, lights, or electrical tools. This hazard exists chiefly in loading and assembly operations. However, rocket ammunition packed for shipment is not any more susceptible than other types of ammunition nor is it susceptible to ignition by external sparks such as those which might be struck from steel wheels and rails.

(3) Rockets should be stored alone whenever possible. However, when combined storage is necessary, chemical-loaded rockets with or without motors may be stored with similar chemical ammunition. Practice or inert-loaded rockets with motors may be stored with fixed and semifixed shell and shrapnel. Rocket motors not assembled to the head may be stored with blank ammunition for cannon or with rockets to which they belong.

m. Inert materials. Inert materials or empty components of ammunition such as drill cartridges, target-practice projectiles, or empty shell should be stored in buildings which afford good protection against moisture and dampness. Dummy or inert ammunition should not be stored in magazines with live or practice ammunition if other storage space is available. If it is necessary to store such items with live or practice ammunition, it will be segregated and identified clearly. They should be cleaned, repainted, and slushed when necessary and should not be allowed to deteriorate. Shell should be carefully stored to guard against damage to the rotating band.

Section III

STORAGE AT SUPPLY POINTS AND DUMPS

175. SUPPLY POINTS AND DISTRIBUTING POINTS.

a. General. The details concerning ammunition supply points, as discussed in this section, are primarily applicable to those installations in the Zone of the Interior and at posts, camps, and stations. A complete discussion of the subject for application to the Theater of Operations (the communication zone and the combat zone) is contained in ordnance Field Manuals.

b. Location. Supply points and distributing points should be located in the best available network of roads and near a railroad.

c. Lay-out. In planning the lay-out of supply points and distributing points, consideration should be given to the following:

(1) AMOUNTS AND KINDS REQUIRED. It is desirable that a field unit supply train be able to take on its complete load from stacks in a straight line or in a single area without having to enter and congest another area of the supply point.

(2) EASE OF ACCESS. They should be on good roads near, but not on, main highways. Conspicuous signs should be posted on roads leading in, and military police should be notified of names and locations of dumps within their areas.

(3) TRAFFIC CONTROL. Roads should preferably be laid out in complete loops instead of turn-arounds. This has an additional advantage in that it provides access to piles from either of two directions. One-way traffic should be established.

(4) SEGREGATION BY LOTS. As a general rule, ammunition should be piled so the lot numbers are easily inspected. Quantities issued to a single unit should be, if practicable, all of one lot.

d. Fire protection.

(1) The principal hazards in the storage of ammunition in the field is fire, which may be spread by hot missiles resulting from explosions in one stack igniting packing material of nearby stacks, or by travel of the fire through grass, weeds, dry woods, etc. Effort should be made, therefore, to provide protective covering for stacks, such as concrete or metal shelters. Firebreaks should be cleared by burning out brush or by turning the soil over, unless the undergrowth is essential for camouflage.

(2) The commanding officer will appoint a fire marshal who will be responsible for rigid enforcement of fire-preventive measures. The fire marshal will prepare rules covering all local conditions and special fire risks. He will exercise strict fire discipline within depot or dump.

(3) Fire extinguishers, water barrels, sand boxes, and other fire-fighting equipment should be provided. A supply of ropes and hooks should be kept on hand to tear down piles of boxes should they catch fire. Spontaneous combustion due to presence of greasy rags or oily waste should be guarded against. The direct rays of the sun on ammunition, especially that containing smokeless powder, is likely to cause spontaneous combustion.

176. STORAGE OF AMMUNITION AND EXPLOSIVES.

a. Classes. When establishing dumps, the following classes of ammunition are considered:

Antitank mines
Bombs (containing explosive D)
Bombs, fragmentation
Bombs, torpedoes, and aerial mines (not containing explosive D)
Boxed artillery ammunition
Chemical ammunition
Fuzes, primers, detonators
Grenades
Mortar shell
Propellent charges
Pyrotechnics
Separate-loading shell
Small-arms ammunition

b. Quantity and distance. These classes should not be stored together. Whenever practicable, the distance between stacks and classes should be in accordance with paragraph 172.

c. Precautions.

(1) Ammunition and components should be stored so that the neighboring piles will not be detonated by the explosion of one pile and so that not all of one type of component or complete round will be lost in any one explosion. There should be at least two piles of every type of ammunition or component stored. It is particularly important that fuzes, primers, detonators, etc., should be distributed as widely as storage facilities permit.

(2) Ammunition piled in the open should be raised off the ground at least 6 inches and protected from rain and direct sun by paulins. If drainage is not good, ditches should be dug around piles. All piles, indoor and outdoor, should be made with liberal use of dunnage and away from contact with walls, barricades, etc., to insure free circulation of air. Where tarpaulins are used, adequate provision should be made for ventilation. The top of the tarpaulin should not rest on the top of the stack or in contact with boxes but should be raised from the stack at least 6 inches.

(3) During the time ammunition is in dumps, advantage should be taken of every opportunity to place each round in good condition for firing. Lost fuze hole plugs should be replaced, burs in threads and rotating bands removed, and any other defect that might affect the serviceability of ammunition should be corrected. However, the work should be done at a safe distance from the piles.

(4) All ammunition should be stored out of the direct rays of the sun.

d. Chemical ammunition. Chemical ammunition should always be stored away from other munitions, and gas shell should always be stored on their bases. The following additional precautions should be taken in storing and handling this type:

(1) Shell should be stored so that a leaky container can be removed immediately upon detection.

(2) Every man working near gas shell should be equipped with a gas mask.

(3) Tubes of oxygen and first-aid equipment should be placed in conspicuous places in charge of a chemical noncommissioned officer.

(4) Should an accident occur and a worker be overcome, first-aid remedy will be applied and a doctor called.

(5) Any type of ammunition exposed to gas must be cleaned with an oily cloth at once.

(6) Conspicuous wind vanes should be set up in places where gas shell are handled.

(7) Munitions containing phosphorus should always be stored alone and water-filled tubs kept available. Phosphorus ignites spontaneously when exposed to air, and submerging in water will extinguish the fire only as long as the material is kept submerged. Leaky phosphorus shell must be kept under water until they can be destroyed.

(8) Pyrotechnics, incendiaries, and HC, CN-DM, and CN grenades should be kept dry.

(9) Full use of dunnage should be made in storing chemical ammunition.

Section IV

PACKING AND MARKING

177. GENERAL.

a. Purpose of packing.

(1) In order that ammunition may reach the firing line in a serviceable condition, it is essential that each unit of issue be suitably

packed to withstand handling, storage, and transportation. Once a unit of ammunition has been removed from its approved container, there is no assurance of its continued serviceability. Therefore, necessary precautions should be taken in its further handling and storage.

(2) When a waterproof container is opened, the contents are immediately subject to the effects of moisture which is the agent most active in causing the deterioration of ammunition. If immediate use of the ammunition is not contemplated, the container should be effectively resealed.

b. Marking.

(1) Marking includes painting, stenciling, and stamping of containers and of the ammunition itself (par. 7).

(2) Explosives and other hazardous articles offered for shipment on a common carrier will be marked to comply with Interstate Commerce Commission regulations. These markings include the ICC shipping name and dangerous commodity designation. In addition, on LCL shipments, certain labels are required to indicate the nature of the contents.

(3) Explosives and ammunition will be marked in accordance with Army Regulation, specifications, and drawings. Standard and special markings are listed in U. S. Army Specification No. 100-2E and are further described and explained in Technical Manuals and in other sections of this manual. Markings furnish essential information, permitting proper handling, storage, and issue of the round or component.

(4) New painting or remarking of ammunition and components should be a facsimile of that on the original container or ammunition unless the Chief of Ordnance issues specific instructions to the contrary. Explosives and ammunition obtained from salvage operations, or materiel whose identification has been lost, should be marked clearly to show the nature of the goods and, if offered for shipment, to comply with Interstate Commerce Commission regulations.

178. PACKINGS.

a. **Design and construction.** The design and construction of packings depend upon the hazard involved, the facilities for storage and transportation, and the protection required for the item packed.

b. Types. Wooden boxes and crates are used more often than other types. The trend in design is toward the use of standard 1-inch, or heavier, lumber. However, veneer boxes with reinforcing cleats and encircling wire have been adopted as standard in several instances. Wire-bound boxes cannot be reused as often as the heavier wooden boxes, but their low cost is an important factor, particularly when reuse of the box is not warranted. Cylindrical, watertight,

metal containers, holding one or more rounds or propelling charges, are used for packing ammunition intended for tropical climates. The ammunition may or may not be packed in fiber containers before insertion in the metal container. Some separate-loading propelling charges are packed in a waterproof bag and then placed in a fiber container. Four general types of packing--boxes, crates, metal containers, and fiber containers—are described below.

(1) BOXES.

(a) End opening. One removable end, permitting boxes to be stacked on their sides and opened without removal from the stacked pile.

(b) Chest type or hinged top. Permits repeated use and easy access to the contents. Most recent types have a toggle-type fastener.

(c) Bolt and wingnut. Bolts and wingnuts hold down the top cover. These boxes are used for small-arms cartridges.

(d) Metal. Used for small-arms cartridge packings and for storing 40-mm ammunition. These sheet-steel containers are sealed by rubber gaskets under the cover.

(2) CRATES. Used for bombs, projectiles, components, and metal powder containers to give added strength and protection, and where packing in a closed box is not necessary. For some types of bombs, only steel crates are used in shipment. Other crates are wooden, some of which may be wire-bound.

(3) METAL CONTAINERS.

(a) Cartridge-storage cases are cylindrical, moistureproof, steel containers for packing separate-loading propelling charges. A test hole is provided in the cover for air-pressure testing.

(b) Metal containers are used for packing single rounds of artillery ammunition, either bare or in fiber container. Eight 60-mm, or four or one 81-mm, rounds are also packed in metal containers. These metal containers are provided as standard for those theaters where waterproofing is essential. The single-round metal containers are cylindrical steel tubes with a detachable screw-type cover. The steel cover is provided with a rubber gasket and is clamped tight to the container by means of a spider, screw, and pressure plate. Cork end felt pads are furnished to provide a snug fit for the round or fiber container in which the round is packed. Some metal containers are provided with test holes for air-pressure testing.

(4) FIBER CONTAINERS. A slip-cover fiber container of the mailing-tube type is used for the packing of complete rounds, separate-loading propelling charges for artillery weapons, hand grenades, assemblies of boosters and fuzes, fuzes, and mortar ammunition. These fiber containers were formerly shipped in bundles of three, held together by two clover-leaf-shaped, metal, end covers. Fiber containers

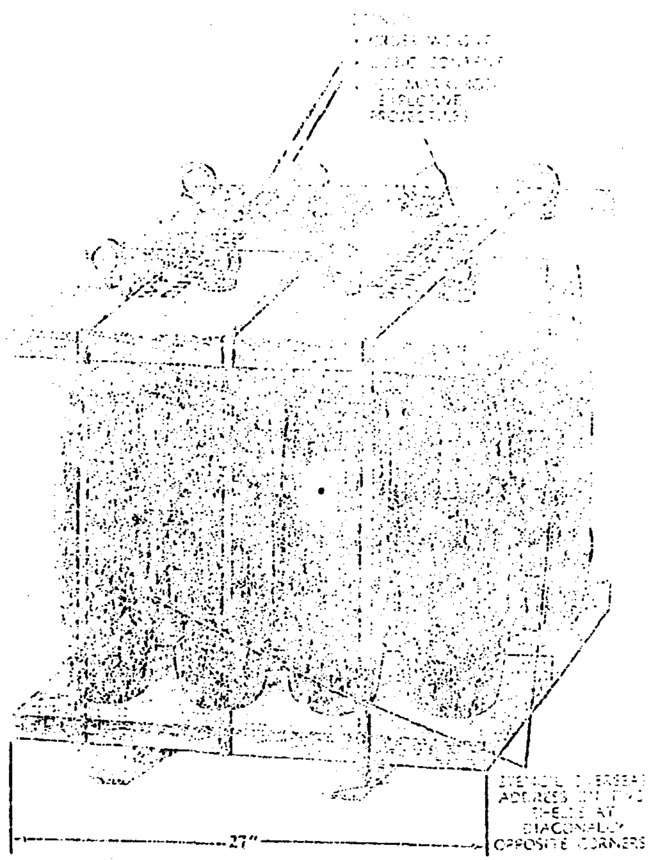


Figure 159 — Palletization of 155-mm Shell

[illegible] rounds (57-mm through [illegible]) [illegible] in [illegible] single-round metal containers. Fiber containers for [illegible] rounds of fixed and [illegible] ammunition have [illegible] the projectile [illegible] and [illegible] to [illegible] case of excessive weight. In [illegible] double-end containers, a U-shaped metal packing stop is used for fuzed projectiles.

f. [illegible]

(a) Metal cans made of terneplate [illegible] are used for packing small-arms cartridges, small components of ammunition, fuzes, rifle grenades, etc., individually or in small quantities, to protect them against moisture. Metal liners for wooden boxes are also used in many types of packing of components, for certain small-caliber complete rounds where a moistureproof container is desired, or for shipments of smokeless powder. Stainless-steel-lined plywood boxes are generally used for storage of nitrocellulose cannon powders.

(b) All-steel boxes of both Army-Navy design are used for storing nitrocellulose cannon powders having a web of 0.019 inch and more. Sheet-steel cylindrical drums are used for black powder, which is contained in a cloth bag inside the drum. The drums are crated for overseas shipment.

(c) Fiber cartons are used for packing primers or small fuzes, a small number being packed in each carton. The carton can be made moistureproof by wrapping in a grade C, type I paper, conforming to U. S. Army No. 100-15 (JAN-P-121), and immersion in dip coating sealing compound conforming to U. S. Army No. 100-54 (JAN-P-115).

(d) Packings known as "jungle-packs" contain additional water-proof containers or envelopes so that the ammunition may better withstand hot humid climates.

e. Palletization (fig. 159) has been authorized to reduce handling time and save man hours in storage and shipment of certain types of ammunition. Pallets are constructed of lumber in accordance with ordnance drawings. When palletized ammunition is shipped, a notation to that effect will appear on the tapship.

179. REGULATIONS.

a. General regulations governing the packing, marking, and shipping of explosives and ammunition are set forth in AR 55-155. All shipments of explosives and ammunition made by the War Department will comply with applicable requirements of Interstate Commerce Commission, Bureau of Explosives Regulations, Port and Harbor Regulations, State and Municipal laws, and pertinent Army Regulations.

b. Explosives and other dangerous articles offered for shipment on a common carrier will be packed to comply with Interstate Commerce Commission regulations, but paragraph 14 (a), section I, of these regulations states that "shipments of explosives offered by or consigned to the War and Navy Departments of the United States Government must be packed, including limitations of weight, in accordance with these regulations or as required by their regulations." Any proposed departure from the requirements of Interstate Commerce Commission regulations must be submitted to the Chief of Ordnance for decision.

c. Military explosive and ammunition are packed in accordance with U. S. Army specifications and drawings. The methods of packing specified are used not only to meet military requirements and protect the articles from damage in transit but are also designed to comply with Interstate Commerce Commission regulations.

d. When shipments of explosives and other dangerous articles are to be made and containers which comply with U. S. Army specifications for the particular article to be shipped are not available, containers complying with Interstate Commerce Commission regulations will be used. This applies particularly to the shipment of deteriorated explosives or ammunition, and to powder, explosives, and loaded components of ammunition obtained from salvage operations.

e. Other regulations concerning packing will be found in the various Technical Manuals, Standard Nomenclature Lists, Ordnance Safety Manual O.O. No. 7224, Ordnance Department Safety Bulletins, and AR 55-470 (shipments by water).

180. SEALING.

a. Packings are sealed for airtightness by closing the test hole of airtight containers or cases with solder or a plug. Fiber containers are sealed with water-resistant adhesive tape at the joint formed by the body and cover, but they are not considered completely airtight.

b. After the contents are properly packed, each container is sealed in some manner which will indicate whether or not the container has been tampered with. The method of sealing depends upon the type and construction of the container. Where metal strapping or wire is used around boxes, other seals are not necessary and will not be used in the future.

181. MARKING.

a. General. This paragraph covers markings for items as packed and shipped. For marking and painting on ammunition items themselves, see basic color schemes given in paragraph 7; sections in

chapter 2 of this manual; and other Technical Manuals on Ammunition.

b. On ammunition. The markings on uncrated bombs and uncrated shell serve also as a means of identification for shipping purposes.

c. On containers.

(1) Containers of ammunition and explosives are marked to provide a ready means of identification as to contents. Packing containers are also marked in accordance with Army Regulations, specifications, and ICC regulations.

(2) With certain exceptions given in AR 55-155, each package of supplies turned over for shipment on a Government bill of lading is marked with:

(a) Name and address of destination of port officer (or code designation).

(b) Name and address of ultimate consignee.

(c) List and description of contents.

(d) Ammunition code symbol, published in ORD 11 SNL's.

(e) Gross weight in pounds, displacement in cubic feet.

(f) The number of the package.*

(g) The letter "U. S." in several conspicuous places.*

(h) Order number or contract number.*

(i) Ordnance insignia.

(j) Name or designation of consignor preceded by the word "From."*

(k) Lot number.

(l) Month and year packed.

(m) Inspector's stamp.

(3) The adhesive sealing strips on fiber containers are in the same color as ammunition item, in accordance with basic color scheme. Thus, blank ammunition has sealing strips in red, to indicate low explosive (black powder). It will be noted, however, that for rounds with high-explosive projectiles, the strips are yellow.

(4) The top of boxes containing ammunition used in both American and British guns (for example, some lots of 20-mm ammunition) are marked "COMMON AMMN."

(5) For further information on regulations governing marking of containers for shipment, consult AR 55-155 and AR 55-470 (shipments by water). Shipping names are published in ORD 11 SNL's.

(6) Markings on boxes, barrels, or crates are made in stencil

*For LCL shipments only.

black or stencil white, whichever is more appropriate. On boxes of ammunition which are stained brown, the marking is in yellow; on unstained boxes, the marking is black. When it is impracticable to stencil or paint the markings on the containers, or when a container is not used in shipping, at least two shipping tags bearing markings should be used. The shipping tags may be of cloth, leather, metal, or waterproof paper, and are attached to the article by wire. The use of writing ink, chalk, or marking material other than waterproof ink or paint is prohibited.

(7) Metal containers are painted olive drab; marking in yellow.

(8) Containers for green bag propelling charge, white bag propelling charge, or section of propelling charge containing the black powder igniter are printed with green, white, or red stripes, respectively. Containers containing igniters only are painted completely red.

(9) Containers for rounds having high-explosive shell have a yellow strip; having chemical shell, a gray strip (superimposed with yellow, red, or green bands to indicate smoke or gas fillers); or having inert shell, a black strip.

(10) Containers for ammunition assembled with shell which have the supplementary bursting charge have stenciled thereon "W/SUPPL. CHG." and the letter "P."

d. **On pallets.** Boxes, containers, or uncrated shell and bombs are packed for shipment and storage in pallets. Pallets are marked so that the shipping name, weight, and cubic feet are stenciled on the top section of the pallet. The overseas address, if any, is stenciled on two boxes, containers, shells, or bombs, both being in diagonally opposite corners of the pallet (fig. 159).

182. LOT NUMBER. Lot numbers are basically described in chapter 1, section II.

Section V

SHIPPING

183. GENERAL. The information contained in this section outlines the special regulations controlling the shipping and transportation of explosives and ammunition. The general regulations are contained in AR 55-155 which apply to government as well as to commercial shipments. Shipments made by military establishments will comply with applicable requirements of these regulations and recommendations. When any difficulties are encountered in complying with these regulations, a report in detail will be submitted to the Chief of Ordnance through appropriate channels.

184. REGULATIONS AND REFERENCES.

a. **Military.** A list of publications controlling transportation of explosives is provided in chapter 5.

b. **Nonmilitary.** Regulations for the transportation of explosives, inflammable, and other dangerous articles by rail, motor vehicles, and merchant vessels are prescribed by the Interstate Commerce Commission (for rail and motor vehicles, see par. 185) and U. S. Coast Guard (for merchant vessels, see Regulations Governing Transportation of Military Explosives on Board Vessels During Present Emergency and Regulations for the Security of Vessels in Port).

c. **State and municipal laws, ordinances, and regulations.** In addition to the Federal laws governing interstate transportation of explosives and other dangerous articles, each state and nearly all municipalities have laws or ordinances regulating the transportation of explosives and other dangerous articles within their jurisdiction. Shipments of explosives and ammunition will comply with applicable requirements of Interstate Commerce Commission regulations, Port and Harbor regulations, State and Municipal laws, and recommendations by Bureau of Explosives.

d. **Rail regulations.** For these regulations, consult "Interstate Commerce Commission Regulations for Transportation of Explosives and other Dangerous Articles by Freight," published by the Bureau of Explosives, 30 Vesey Street, New York, New York; and see specific application by reference to items involved in index of Consolidated Freight Classification.

185. INTERSTATE COMMERCE COMMISSION REGULATIONS.

a. The transportation of explosives and other dangerous articles within the limits of the jurisdiction of the United States is regulated by Federal law, Act of March 4, 1909, chapter 321, sections 232 and 234 (35 Stat. 1134), as amended by the act of March 4, 1921, chapter 172 (41 Stat. 1444-1445), and the Dangerous Cargo Act of October 9, 1940 (Public No. 809, 76th Cong.). Violations of this act are punishable by severe fines and imprisonment.

b. Section 233 of the above-mentioned act, as amended, reads in part as follows: "The Interstate Commerce Commission shall formulate regulations for the safe transportation, within the limits of the jurisdiction of the United States, of explosives and other dangerous articles, * * * which shall be binding upon all common carriers engaged in interstate or foreign commerce which transport explosives or other dangerous articles via any common carrier engaged in interstate or foreign commerce by land or water." Section 235 of the Act of March 4, 1921 requires the shipper of explosives and other dangerous articles to describe, pack, and mark all packages properly, and to

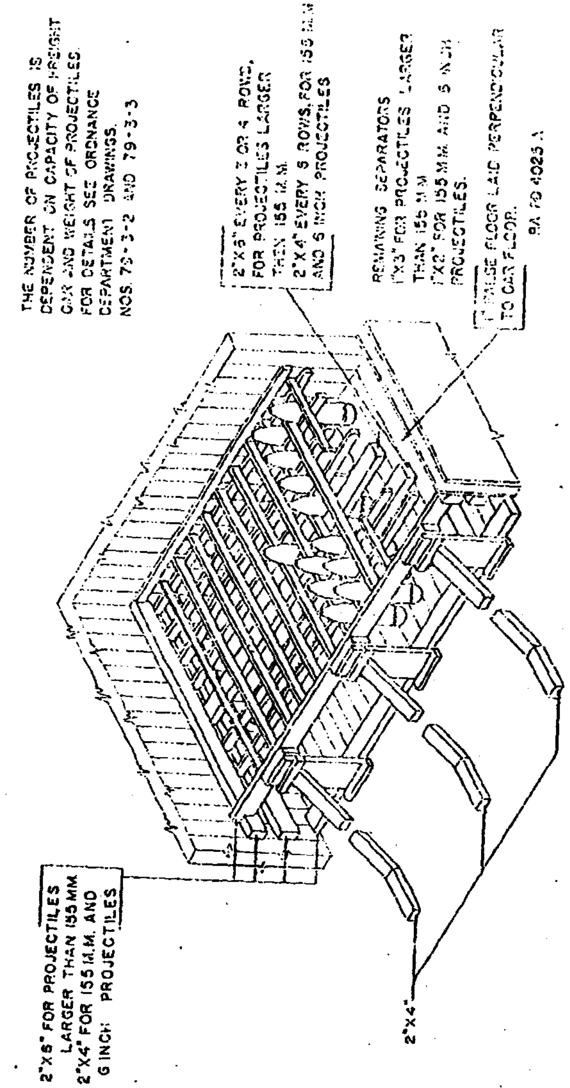


Figure 160 — Method of Stowing Shell in Freight Cars

inform the agency transporting the packages of the true nature of contents. Violations of this act are punishable by severe fines and imprisonment. ICC Freight Tariff No. 3 prescribes regulations for transportation by water.

c. Under the authority of the above-quoted act, as amended, the Interstate Commerce Commission has published regulations governing the transportation of explosives and other dangerous articles by rail, motor vehicle (highway), and vessel.

186. U. S. COAST GUARD. The U. S. Coast Guard prescribes regulations governing the storage, stowage, and use of explosives and ammunition on board merchant vessels. It is responsible for security and supervision of vessels, which includes barges, unless specifically exempt. (See *Regulations Covering Transportation of Military Explosives On Board Vessels During Present Emergency.*)

187. COMBINATION OF TYPES FOR SHIPPING BY RAIL OR MOTOR VEHICLE.

a. Regulations of the ICC restrict the shipping of different types of explosives and ammunition in the same car or truck. These restrictions are specified in the Loading and Storage Chart of Explosives and Other Dangerous Articles and published in ICC Regulations. The restrictions may be summarized as follows:

(1) Bulk initiating explosives may *not* be shipped dry.

(2) Initiating components such as detonating fuzes, blasting caps, boosters, and bursters may not be shipped with any other high-explosive item except when assembled thereto. A further exception is permitted in case of emergency certified by the Office of the Chief of Ordnance, in which case initiating components may be shipped with high-explosive components provided they are separated by a 3-foot sand barricade.

(3) Fireworks may not be shipped with high explosives or black powder.

(4) Chemical agents may not be shipped with high explosives or black powder.

188. RAIL SHIPMENT.

a. **Loading.** When loading freight cars for shipment (figs. 160, 161, and 162), Bureau of Explosives Pamphlets No. 6 and 6A should be consulted. These pamphlets govern the methods of loading, staying, and bracing of carload and less than carload (LCL) shipments of explosives and other dangerous articles, loaded shells (projectiles), and loaded bombs *not covered in ordnance drawings.* Ordnance drawings, specifications, and standard practice sheets contain certain technical information required in the carloading and storage and marking,

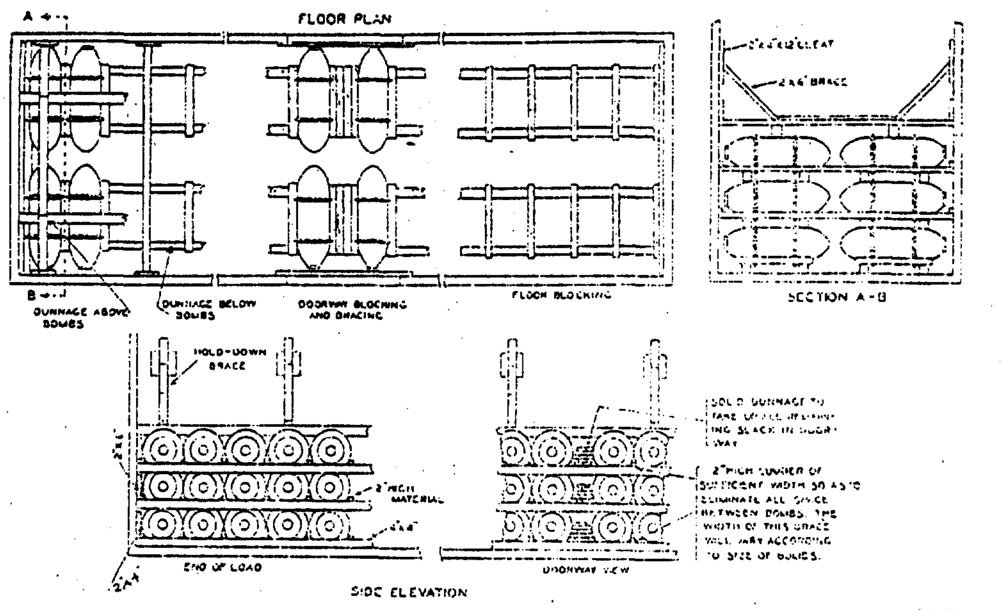


Figure 161 — Bracing of 300-, 500-, and 500-pound Bombs in Freight Cars

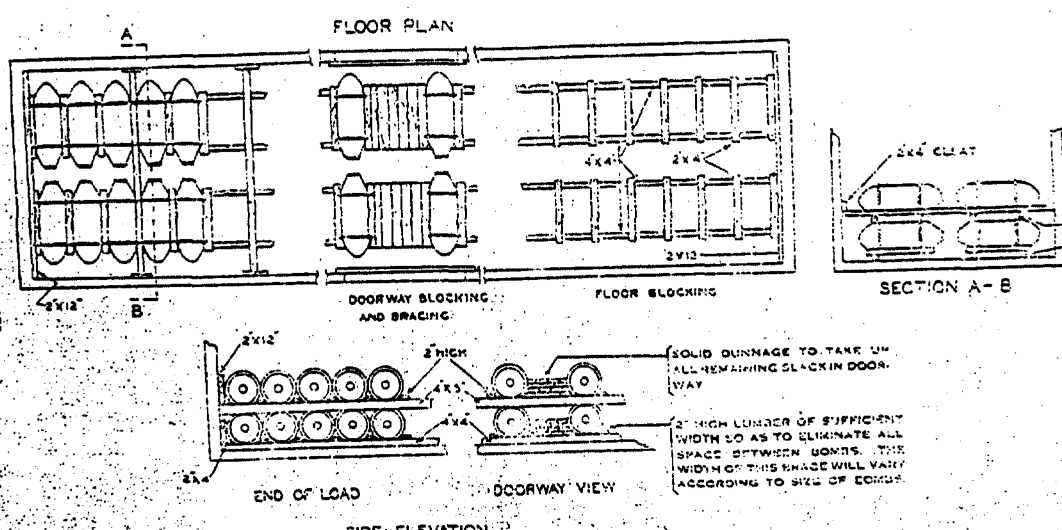


Figure 162 — Bracing of 1000- and 1100-pound Bombs in Freight Cars

of ammunition. They may be obtained by applying directly to the Office of the Chief of Ordnance. The Chief of Ordnance has compiled a series of volumed drawings, covering ammunition storage, loading, and blocking which are in class and division 19-43. Items are listed by Ammunition Identification Code Symbol, packing, drawing, and abbreviated nomenclature. For information on legal requirements, consult ICC regulations.

b. The cargo should be studied and decision on appropriate stowage made beforehand. The car best suited for the needs at hand should be ordered. When the car arrives, it should be given a thorough sweeping and inspection for protruding nails and bolt heads, which must be removed or covered with wood. The sides of the car should be boarded up where necessary to obtain an even bearing and proper dunnage (see Bureau of Explosives Pamphlets). Substantial gangways should be provided; obstructions which may prevent free entry to the car removed; the immediate vicinity cleared of leaves, dry grass, and other inflammable materials; and the brakes set and wheels chocked. During loading operations, the car and magazine door should be closed when engines or speeders are passing. Cars should not be left partly loaded unless it is impossible to finish loading at one time, in which case car doors must be securely locked. After loading, the shipment should be properly braced and stayed, the car properly sealed and placarded (see ICC regulations), and a permanent record of car numbers kept. Too much importance cannot be placed on proper blocking and staying. In many cases the bracing may seem excessive for the packages involved; however, if a car loaded with packages of explosives, moving at a rate of 5 miles per hour, should bump a solid train of loaded cars, the packages may be subjected to a pressure as high as 5 times the total weight of packages involved. For example, under these circumstances a 58-pound box momentarily approaches 290 pounds of pressure. In unloading cars the same safety precautions that have been outlined above should be observed. An inspection must be made of the method of blocking, staying, and condition and serviceability of contents before releasing a car for shipment. All cars that have contained explosives should be carefully swept and all placards removed. Sweepings should be thrown in running water, burned, or placed in a metal receptacle for later disposition. All shipments received in a badly damaged condition should be reported through channels to the Chief of Ordnance.

c. Certified cars. Interstate Commerce Commission regulations require the use of a "certified car" for shipment of many explosives; refer to ICC Freight Tariff No. 4 for exceptions. A "car certified" for shipment of certain explosives (see ICC regulations) must be signed in duplicate by a representative of the carrier and of the shipper after shipment is loaded and properly braced. Two of these must be

attached outside the doors or to the sides of the car, one on each side, in addition to required explosive placard.

d. Spotting of loaded cars. Loaded railroad cars will not be left in the open area between magazines, where they may act as an intermediate step in propagation of an explosion. Railroad loading and unloading facilities for ammunition should be separated from inhabited buildings, public highways, and public railroads in accordance with quantity-distance requirements, chapter 3, section II. Cars should not remain at the loading or unloading facilities longer than 24 hours. Not more than one car should be permitted at the unloading facilities at one time (this does not apply to Ports of Embarkation). Additional cars should be held on an isolated spur. Cars containing ammunition should not be in groups of more than three when spotted on the spur, and the groups should be separated by 400 feet. Before cars containing explosives and ammunition are moved by a locomotive, the air brake couplings must be coupled and tested to assure that the air brakes are in proper working condition. When cars are spotted and engines are detached, the hand brakes must be set. During the moving of a car by pinchbar, a man must be stationed at the hand brake at all times. "Dropping," "bumping," "kicking," or the use of the flying switch with cars loaded with explosives and ammunition is prohibited.

e. Inspection of incoming shipments.

(1) All railway cars before entering a military installation, must receive complete exterior inspection. This includes examination of car seals for tampering, and verification of numbers against shipping papers and bill of lading to insure that cars have not been opened in transit. If car seals have been tampered with or do not correspond with documents, or sabotage is suspected, the car should be inspected by authorized personnel at a special location.

(2) Complete interior inspection is made when the cars are opened. Check contents for conditions and serviceability, and blocking and staying methods if damage is prevalent.

189. WATER SHIPMENTS.

a. Regulations. Shipments of explosives and other dangerous articles aboard vessels (including lighters and barges) by commercial service shall conform to the regulations prescribed by the U. S. Coast Guard Regulations Governing Transportation of Military Explosives on Board Vessels during present Emergency, and ICC Tariff No. 3. These regulations permit the transportation of military explosives and ammunition in accordance with requirements of the War and Navy Departments. AR 55-470 contains regulations governing transportation of military explosives, inflammables, and chemical materials. Also regulations of ports and harbors of the cities and states affected should be consulted and complied with.

b. Precautions and safe handling.

(1) Transportation of explosives, except small-arms ammunition, on ships carrying passengers is prohibited except for combat loading and other operational requirements which may be excepted upon decision by competent authority. Equipment to be used for shipment should be inspected and declared as acceptable by duly authorized port authorities. Regulations covering use of fires, stoves, gasoline, matches, smoking, flags, anchors, lamps, hooks, etc., should be consulted and strictly complied with. Persons under the influence of liquor or drugs should not be permitted on board a vessel while loading, unloading, or transporting of explosives and ammunition is in progress. No repairs other than emergency repairs shall be undertaken while any explosives are on board as cargo, and operations with equipment necessitating the use of open flames or acid is prohibited except upon special permission of port authorities. Explosives shall be stowed and segregated by groups according to Coast Guard regulations.

(2) Ammunition or explosives in bulk may be stowed in a hold before or after other cargo, provided all precautions are made against the hazard of articles being dropped from the sling. As far as practicable all work in connection with the construction of a magazine, or other conditioning of holds, decks, or hatches, shall be completed prior to actual loading of ammunition or bulk explosives.

(3) The floors of all magazines and holds shall be cleared of all rubbish, discarded dunnage, and spilled explosives, and swept broom clean before any ammunition or explosives are loaded onto the vessel. Buildings shall also be examined and any residue of previous cargo removed therefrom.

(4) The hatches of the vessel will be kept closed except during loading or unloading operations, and when so closed will be covered with tarpaulin and battened.

(5) If loading or unloading is not completed during operational time, proper precautions will be taken to guard and protect the cargo against fire, and a sufficient crew will be left in charge to handle the vessel in case of emergency. Docks should be kept clear of rubbish, etc. Ammunition and explosives should not be left on a dock or elsewhere unless proper guard is provided or delivery made to authorized persons. Explosives and ammunition will not be left on board overnight unless such action is necessary incident to their transportation. Lighters should not be tied up to that part of a vessel or dock where the fireroom or boiler is located. Explosives should be kept as far away from the boiler room and engine room as is possible.

(6) The use of oil or chemical burning lamps or lanterns is prohibited when loading. Only electric lanterns will be used when a movable artificial light is necessary.

(7) Lighters, barges, scows, and tugs engaged in hauling vessels or vessels berthed at an ammunition loading pier loaded with explosives must have their funnels or smoke stacks covered with screening of suitable size to prevent the escape of sparks. This screening must be renewed whenever it is broken.

(8) Magazines (cargo space) for explosives and ammunition and all metal obstructions and constructions must be lined entirely with wood or authorized wood substitute not less than 1 inch thick, nailed with cement-coated nails and countersunk.

(9) Explosives awaiting removal or delivery should be stored outside the dock or wharf when practicable and every possible effort must be made to reduce the time of such storage. Storage of these materials must be in a safe place and away from dangerous articles.

(10) *Packages of explosive and ammunition must not be handled roughly, thrown, dropped, dragged, or rolled over each other or over decks.*

(11) Metal hand hooks shall not be used in handling packages of explosives. Cant hooks shall not be used for raising or lowering barrels, drums, or other containers of explosives.

(12) Containers of explosives showing evidence of damage or leakage shall not be accepted for transportation or storage on board a vessel. Recoopering or repacking of damaged or faulty containers should be done at a safe distance from the vessel.

190. MOTORTRUCK SHIPMENTS.

a. **Regulations.**

(1) Regulations governing transportation of ammunition and explosives by truck is fully covered by ICC Motor Carrier Regulations, part No. 7, for commercial carrier, and AR 55-155 for government-operated vehicles, and will be strictly adhered to. Most states and cities, towns, villages, etc., have their own laws concerning the transportation of explosives and other dangerous articles within their jurisdiction. The local authorities of those sections through which motor shipments will pass should be consulted and their rules, regulations, and recommendations as to the best route to follow in order to avoid congested areas, be strictly adhered to. On request, local public safety authorities will provide escorts or guards for movement of explosives through their jurisdiction. If compliance with these rules is impracticable, the matter shall be referred to the Chief of Ordnance in detail.

(2) Except in cases of emergency, shipments of ammunition or explosive materials, except small-arms ammunition, will not be shipped by motortruck without prior approval of the War Department. This does not apply to local or nearby hauling but it is intended to prevent truck shipment where rail or water facilities are available.

(3) Explosives and other dangerous articles will not be shipped by any commercial highway carrier nor will local drayage thereof by any commercial concerns be engaged, unless the carrier or drayage concern files a certificate with the controlling transportation officer stating that said carrier or drayage concern will comply with all laws and regulations promulgated by federal, state, and local governments and municipalities that may be applicable to and govern each particular shipment of explosives and other dangerous articles. Motor carriers not licensed by the ICC may transport explosives in interstate commerce provided parts 2, 3, 6, and 7 of the Motor Carrier Safety Regulations are observed.

(4) When government-operated vehicles are used in transporting explosive material, the shipping officer will take all necessary and reasonable precautions to insure safe transit. Except in time of emergency, the shipping officer will be responsible for the observation of all ICC regulations applicable. If the commanding officer of an arsenal or depot or a general or field officer of the line declares the shipment as an emergency, the shipping officer will take every reasonable precaution to insure safe movement of the explosives, toxic gases, or other dangerous articles while in transit on government reservations and public highways.

(5) When trucks have been loaded and ready for movement, the drivers will be informed of the true nature of the explosives on the trucks, the fire hazards, the methods to be used in fighting fires involving the truck or cargo, the missile distance in case of explosion, proper distance to maintain between other trucks, and any other information that will bring about safe delivery of the shipment to its destination.

(6) Any explosive or ammunition accepted for rail shipment is equally acceptable for movement by truck (par. 188), and loading and storage chart for items that may be loaded on motor vehicles is similar to that used on railroad cars. For further description, see ICC, part No. 7. In passenger-carrying vehicles, however, explosives and chemical agents may not be transported, except small-arms ammunition, laboratory samples, and class B solid poisons, or shipments weighing less than 100 pounds.

b. Precautions and safe handling.

(1) *Every precaution against fire must be observed.* Trucks should be inspected daily to ascertain that electric wiring, lights, brakes, gasoline tanks, and lines are in good working order, the engine clean of dust and oil, and the engine pan is free from accumulations of dirt and grease. Accumulations of oil or grease splashed from the universal joint, transmission, or other moving parts, on the under side of the footboards or body of the car should be cleaned thoroughly after each long trip or day's work. Leaking gasoline tanks or lines should be repaired immediately, and lighted cigarettes, cigars, pipes,

and open lights must be kept away from the vicinity when filling gasoline tanks. When necessary to use matches, only safety matches may be used. They must be kept in a metal container in the tool box. Use of "strike anywhere" matches is prohibited. The amount of waste in a truck should be kept to a minimum, and oily and clean waste should be separated. Trash should not be permitted to accumulate in the tool box.

(2) All trucks will be provided with at least one properly filled fire extinguisher. All drivers and other employees should be instructed as to the best methods of extinguishing gasoline fires with Pyrene and should be impressed with the fact that in nearly all cases there is time to extinguish a fire, as it takes an appreciable time to heat ammunition to the point where it will explode. A box containing 3 cubic feet of sand should be carried on each vehicle.

(3) When ammunition and explosives are being transported in a convoy of trucks, it is advisable that they do not become widely separated but a safe distance between each truck be maintained to avoid danger of collision. The convoy should be stopped once each hour during the trip, to inspect each truckload, in a location not within or close to limits of cities, towns, or municipalities. Driving through congested areas should be avoided when possible. Trucks should maintain a moderate speed and make a full stop at railroad crossings. Unauthorized persons will not be permitted to ride on trucks. If a truck catches fire, the other trucks will proceed to a safe distance in case an explosion may occur and guards posted at a distance of several hundred yards on each side of the truck to stop all traffic. In case a truck breaks down and cannot be towed to its destination by one of the other trucks, a two-man guard should be stationed and the post to which the convoy is proceeding should be notified so that a truck can be dispatched at once with loading personnel to relieve the disabled truck of its load.

(4) Fuzes or other detonating agents should not be transported with other explosives. An exception is ammunition for cannon shipped with fuzes or boosters assembled. The load should be well braced and stayed and tarpaulin spread to protect the load from the weather and from sparks. As an ICC War Emergency Regulation, fuzes may be transported with other explosives if a 3-foot sand barrier separates the fuzes from the other explosives.

(5) Explosives and ammunition should not be unloaded or piled immediately back of the exhaust. This regulation is intended to apply to bulk shipments of ammunition by motor truck. No regulations will be construed to prohibit the carrying of complete rounds of artillery ammunition, including fuzes and primers, in one vehicle by combat units.

(6) When transporting artillery ammunition, all projectiles should be parallel to the side of the truck so that the projectile will

not roll back against the tail gate of the truck. If it is necessary to place more than one layer of projectiles in the truck, strips of planking should be placed over the first layer of projectiles to protect the rotating bands from becoming deformed through contact with other projectiles when the truck is in motion.

(7) No container of explosives or other dangerous articles may be accepted by a motor carrier if damaged or in a leaking condition. Any container found broken or leaking during transit may be repaired when practicable and not dangerous. Repairs should be done in accordance with best and safest practice known and at least 100 feet from other explosives or ammunition. If the damaged container cannot be repaired, it should be reinforced by heavy wrapping paper and twine, placed in another storage box, and surrounded by dry fine sawdust, dry clean cotton waste, or wads made from dry newspapers and box cover securely attached. When leaking and damaged container is beyond recooperage, it may not be transported beyond the minimum distance necessary to reach a place where the explosive may be disposed of with safety.

(8) Trucks must have pneumatic rubber tires and brakes on all four wheels.

(9) All artificial lighting must be electric.

(10) Fuel tank inlets and connections should be equipped with a device to relieve internal pressure and placed so that no overflow can spill on the exhaust, and exhaust pipes will be protected by a properly constructed flame baffle.

(11) The floors of all vehicles must be tight, and exposed metal on the body covered or protected with wood or nonmetallic material.

(12) Lighting equipment on vehicles should be in conformance with the standards prescribed by the ICC or the laws of the state within which the vehicle is operating.

(13) Motortrucks containing explosives will never be taken into a garage or repair ship for repair or storage unless it is an open, sun-shaded garage where no open-flame lighter burner is in use.

(14) When possible explosives will be transported during daylight.

(15) ICC rules forbid transportation of explosives on any full or pole trailer.

(16) Interiors of trucks must be free of bolts, nails, or other projections which may damage containers.

(17) The entire load must be within the body of the vehicle, and the tailboard of gate must be closed and secured during transit.

(18) The engines of all trucks must be stopped, all brakes set, and wheels chocked before loading and unloading.

(19) Loaded trucks will not be left in the open area between magazines as they may act as an intermediate step in propagating an explosion.

(20) Refueling should be reduced to a minimum. The electric ignition system should be turned off and the engine stopped during the refueling process. If the engine is provided with a magneto, it should be grounded.

(21) For any continuous trip longer than 8 hours, the driver must be accompanied by an assistant. Smoking will not be permitted in the cabs of vehicles transporting explosives. The car will not be left unattended on a public street or highway.

(22) Every shipment of dangerous explosive will be delivered only to a person authorized to receive it, except such shipments as are placed in magazines which are immediately thereafter locked.

(23) Motor vehicles carrying explosives or ammunition will have the prescribed placarding with lettering no less than 3 inches high on a suitable background. Four "Explosive" signs are required, one on the rear, front, and on each side. When transporting more than one class of explosives or dangerous articles, no more than one kind of sign lettering or placard need be displayed and that one must be the one which designates the most dangerous article being transported.

(24) In case of accident, all unbroken packages and as much of any broken packages as possible will be carefully gathered and removed to a place of safety in order to prevent fire or explosion. Care should be taken not to produce sparks. In the event that a motor vehicle is entangled with another or with an object or structure, no attempt will be made to disentangle the vehicle until the load is removed to a place 300 feet from the vehicle or any habitation. Inhabitants and other vehicles will be warned of the danger.

(25) When explosives and ammunition are being transported by truck from railroad loading and unloading facilities to or from the magazine area, a route should be selected which avoids travel through congested areas of the post.

Section VI

INSPECTION AND SURVEILLANCE

191. DEFINITIONS.

a. **Inspection.** Periodic and special visual examinations which may include gaging, weighing, or investigation of components as required for the purposes of determining the current serviceability of the stocks on hand and detecting evidences of deterioration.

b. **Maintenance.** The care taken and work done to keep the ammunition in good condition.

c. Surveillance. Observation, inspection, investigation, test, study, and classification of ammunition and ammunition components and explosives in movement, storage, and use, with respect to degree of serviceability and rate of deterioration.

d. Grading. See chapter 1, section II.

192. INSPECTION OF MAGAZINES AND MAGAZINE AREAS.

a. Magazines and magazine areas should be inspected once a month, or more frequently as may be required by regulations and conditions, to see that all conditions are normal, that neither humidity nor temperature is or has been too high within the magazine and that containers are in a satisfactory condition.

b. The following is a summary of conditions that should apply when ammunition is inspected:

(1) The location of magazines should conform to the quantity-distance tables in regard to distance from inhabited buildings, from public highways and railroads, and from each other.

(2) The magazine area should be well guarded and protected against fire.

(3) The required firebreaks should be provided and free from rubbish and inflammable material.

(4) The magazines should be well and suitably constructed.

(5) The magazines should be in good repair, dry, and well ventilated.

(6) The interiors of magazines should be clean and neat with stores arranged in orderly piles.

(7) The requirements of the Mixed Storage Chart, paragraph 173, should be met.

(8) The stores should be properly identified by lot number and piled with no more than one lot in each pile.

(9) Outer containers should be securely closed.

(10) Loose rounds, damaged containers, empty containers, paint, oil, waste, rags, tools, and other prohibited articles should not be present in the magazine.

(11) All ammunition, explosives, and load components (except small-arms ammunition) should be stored in segregated magazines and not in buildings used for other purposes.

(12) Exudate should be removed from magazines promptly.

(13) Files of publications should not be kept in magazines.

193. SMOKELESS POWDER.

a. Smokeless powder in bulk and separate-loading propelling charges should be inspected to see that all containers have lids fas-

tened firmly in place, that containers are airtight and in good condition. They should be examined for evidence of having been subjected to moisture and dampness and, in warm weather and climates, the records of the maximum-minimum thermometer examined. Metal containers of separate-loading propelling charges should be air-tested. Air-testing personnel should be familiar with the odor of decomposing powder and should note carefully the odor from each container as it is opened for air test.

(1) When smokeless powder reaches an age at which it may be expected to deteriorate with increased rapidity, each container is inspected at least every 12 months. Propelling charges of lots that satisfactorily passed previous inspection should be reinspected at 12-month intervals. If it appears that it will be necessary to withhold inspection so that the elapsed time will be greater than 14 months, prior authority will be obtained from the Chief of Ordnance. Methods of inspection and tests to be performed are laid down each year by the Chief of Ordnance and published in WDSB 9-AMM 7.

(2) Where the number of defective propelling charges in any one lot reaches 10 percent, the balance of the lot will thereafter be inspected at 6-month intervals.

b. During inspection, minor repairs such as tightening lacings and replacing gaskets should be effected.

c. In large magazines, instead of dating each methyl-violet test paper individually, a record may be kept in the magazine of the date of inspection. If any lots containing such undated papers are shipped elsewhere, the date of last inspection which normally appears on the test paper will be shown on the shipping ticket.

194. FIXED AND SEMIFIXED AMMUNITION AND GRENADES.

a. All stocks on hand should be inspected to see that they can be readily identified as to kind and lot number and that the ammunition has not been subjected to moisture and dampness. Containers should be examined to see that they have not been opened nor individual rounds removed from their sealed containers. Serviceable rounds turned in by troops should be examined to see that they have been properly repacked and sealed. Unserviceable rounds on hand should be examined to see that they are packed in closed containers and inquiry made to ascertain that they have been reported for disposition.

b. When any large number of rounds of fixed or semifixed ammunition has been in storage 5 years or more, provision should be made for the inspection of the propelling powder from representative lots of the rounds. This requires disassembly of the round and should be done with extreme care by experienced personnel only. Request may be made of the appropriate service command for shipping representative rounds of the lots to ordnance establishments or for an ammunition inspector to supervise the disassembly and inspection. These representative rounds should be examined as follows:

(1) Three packages representing each lot will be removed from the magazine to a location in accordance with safety requirements, and one round of ammunition will be selected at random from each package. These rounds should be removed from the magazine and disassembled with care. Immediately after the shell is removed from the cartridge case, the odor from the powder will be noted. All instances of the odor of nitrous fumes will be reported. In general, any charge containing an excess of one percent deteriorated grains will have a marked odor of nitrous fumes. If nitrous fumes are detected, the smokeless powder from that round will be destroyed, the primer fired, and the balance of the round shipped to the nearest ordnance depot. The entire lot will then be held for disposition.

(2) Semifixed ammunition will be inspected as described above except that, when the charge is contained in bags, the bags only will be inspected for partial or total discoloration and subjected to a manual test to determine the serviceability of the cartridge case cloth. Rounds containing bags which are discolored or spotted, in which the bags are weak due to deteriorated smokeless powder, will be disposed of as described above.

(3) Mortar shell, grenades, mines, and rockets are inspected as in subparagraph a, above, except that extreme care is taken to see that all grenades and grenade fuzes are in containers which are so effectively closed that the articles cannot be easily removed and handled.

(4) A report in duplicate for each lot inspected will be forwarded, through channels, to the Chief of Ordnance.

e. Cartridge cases should be inspected, as occasionally burs, projections, and slight imperfections are formed on the mouth of cases during seating or crimping operations on an assembling machine. Such irregularities must be removed so that the rounds may chamber correctly. The use of power-driven grinding wheels on loaded material is prohibited. Although it is preferable that no filing or grinding be done on loaded cartridge cases, the careful use of a file for this purpose may be permitted when necessary. When filing, the rate must be limited so that the heat generated will not be dangerous. Protection should be given the primer.

195. SMALL-ARMS AMMUNITION.

a. TM 9-1990 and WDSB 9-AMM 4 should be available for reference.

b. An examination should be made to verify the following:

(1) That all ammunition on hand is properly identified.

(2) That outer container seals have not been broken or liners opened.

(3) That covers of partly filled outer containers are firmly fastened.

(4) That an excessive quantity of grade 3 ammunition has not accumulated.

(5) That grade 3 ammunition has been reported (par. 8).

(6) That there is no great accumulation of serviceable rounds of ammunition not packed in clips or bandoleers or in the regularly prescribed manner.

(7) That there is no accumulation of otherwise serviceable ammunition not identified by lot number.

c. The contents of representative containers of lots that have been in storage for 1 year should be inspected for corrosion, season cracking, dents, or other defects of the cartridge case, and for loose bullets or split tracer bullets.

d. Serious defects should be reported at once and, if the number of defective cartridges is greater than 20 percent, the lot should be held for instructions from the Chief of Ordnance.

196. BULK EXPLOSIVES.

a. **High explosives and black powder.** Black powder in bulk, practice bomb and smoke-puff charges, TNT in bulk and blocks, explosive D, and dynamite should be examined to see that the containers are in good condition, that there are no open containers, and that explosives are not sifting from the containers. Black powder containers should be examined for rust and for evidence that containers have been opened in an improper manner, such as by the use of a cold chisel, hatchet, or other unsuitable tool. Dynamite containers should be examined for signs of exudation and other evidence of nitroglycerin on the case or on the floor.

b. **Bulk powder (smokeless).**

(1) Bulk powder of lots that satisfactorily passed previous inspections should be reinspected at 12-month intervals. The action provided in paragraph 193 a applies when it appears the period will be greater than 14 months.

(2) Bulk powder from lots in which 10 percent or more of the lot was found defective will be reinspected at 6-month intervals. Each box will be opened. If the powder smells of nitrous fumes, or if the N/10 methyl-violet paper has turned white, that box will immediately be segregated and subsequently disposed of. Bulk powder segregated will be reported on Ammunition Condition Report as grade III for disposition by the Chief of Ordnance. If neither of the above defects are found, a new dated N/10 methyl-violet paper will be placed in the box, and the box returned to storage. If the amount of defective powder in any one lot equals 10 percent of the

lot, the balance of the lot will be inspected thereafter at 6-month intervals.

(3) For further information, see WDSB 9-AMM 7.

197. SEPARATE-LOADING SHELL.

a. Separate and unfixed shell should be inspected to see that they are piled in the manner, and with the clearance, prescribed in chapter 3, section II. Shell should be inspected for rust or corrosion and some of the fuze hole plugs should be removed to see that the threads are not burred or rusty and that the cavity is clear. Fuze hole plugs which require excessive force to remove should not be removed in the magazine. When necessary to remove such plugs, barricaded protection should be provided. Bands should be protected against dents, cuts, and pressure from upper layers of shell. Shell should be examined to see that they are properly painted and marked as required. TNT or amatol shell should be examined for exudate. Any exudate formed on shell or the floor should be scrubbed up with hot water or acetone. Exuding shell should be reported and held for disposition. Exudate is an oily brown liquid that oozes out around the thread in the nose of a shell. It is inflammable and may carry small particles of TNT. If the exudation is slight, the service command or department ordnance officer may permit the shell to be used after the exudate has been thoroughly cleaned off. If the exudation is excessive and drips on the other shell or the floor, the shell will not be used.

b. When it becomes necessary to recondition the exterior surfaces of projectiles, they should first be thoroughly cleaned. Metal does not stop rusting unless all signs of rust are removed from the shell. Light engine oil should be applied and cleaned off with dry-cleaning solvent after 2 or 3 weeks; then paint, with one coat of primer and one, or two if necessary, coats of paint. Provision must be made for stenciling lot numbers and other identifying marks on projectiles and storing them so that the shell may be readily identified by lot number.

198. BOMBS. The requirements for the inspection of fragmentation bombs are similar to those for fixed ammunition. General-purpose bombs are inspected to see that the regulations laid down for storage are strictly complied with. Examination should be made for exudate, rust, and corrosion. Fin assemblies should be protected. Fuze hole plugs should be removed from representative sample to see that threads and cavities are in good condition. Painting and marking should be in accordance with regulations. Exuding bombs are cleaned the same as exuding shell (par. 197 a), but there are no restrictions as to their issue.

199. SUBMARINE MINE EXPLOSIVES. All submarine mine explosives, including bulk TNT and blasting caps, should be inspected annually. The inspection of TNT will be made as required by paragraph 196 and the inspection of electric blasting caps as required by paragraph 200. In addition, representative samples will be tested with an approved-type electric blasting cap circuit tester. Any questionable blasting caps should also be tested with the circuit tester.

200. FUZES AND SMALL ITEMS. Fuzes and other small loaded components and ammunition items should be examined to see that they are stored in sealed containers and well protected against moisture. Partly filled outer containers are examined to see that they have been properly resealed. A check should be made to see that the components are suitable for use with the ammunition on hand and that the required number is available. Components which have been in storage more than 1 year will have a representative outer container of each lot opened and the contents examined for rust, discoloration, and corrosion. Satisfactory items are resealed by resoldering containers or sealing with friction tape and a coat of shellac. Questionable items will not be issued but will be reported to the Chief of Ordnance for disposition.

201. PYROTECHNICS. Pyrotechnics should be examined to see that all containers are in good condition, and that they are effectively closed so that the contents cannot be easily removed or handled.

202. CHEMICAL AMMUNITION. Chemical ammunition should be inspected to see that it is stored so that any leaky container can be readily removed and that facilities for handling leaky containers are available. The ammunition should be examined monthly for leaks and every 6 months for rust or corrosion. Boxes should be examined to see if there are any instructions thereon requiring the destruction or use of the contents by a certain date. Containers which develop leaks should be reported, through channels, to the Chief of Ordnance. Such reports should include information as to type, lot, date discovered, nature of leak, and whether apparently caused by defective material or improper handling, and disposition made of container or disposition recommended.

203. INERT COMPONENTS. Inert or empty components of ammunition should be inspected to see that they are properly protected against rust and corrosion, or if they need a renewal of a protective coating of paint or grease.

204. OUTDOOR STORAGE. Ammunition stored outdoors should be frequently inspected for signs of deterioration or loose components.

205. REPORT OF UNSERVICEABLE AND DEFECTIVE AMMUNITION.

a. When the material in the hands of troops is inspected, inquiry should be made as to any ammunition failures experienced since the date of the last inspection and whether such failures have been reported. If no report has been made through channels to the Chief of Ordnance, all available details of failures will be collected and so reported.

b. If the inspector finds defects in ammunition which will require the expenditure of labor or funds to correct, he should take care to examine a sufficient number of containers or rounds to insure a report on average conditions and not isolated cases. The examination of fire containers, selected at random, should be sufficient for a report that will reflect average conditions.

206. PUBLICATION FILE.

a. A file of pertinent Technical Regulations, Technical Manuals, Field Manuals, WDSB's, Ordnance Field Service Bulletins, and Ordnance Department Safety Bulletins, together with a copy of the Ordnance Safety Manual, O.O. Form No. 7274, will be kept complete and up-to-date. The service command or department ordnance officer or his assistant should determine, when inspecting ammunition at a post, camp, or station, that such files are available and their contents thoroughly understood.

b. Additional information regarding inspection and surveillance may be found in chapter 5.

Section VII

RENOVATION

207. DEFINITIONS.

a. Renovation denotes all activities, necessary to place ammunition in a serviceable condition, which involve disassembly of the item. Such disassembly does not mean that which is involved in ordinary operation such as the fuzing and unfuzing that may be performed by a gun crew, but that which involves the opening of a joint which originally was intended to be permanent, as shown by crimping, staking, or cementing. Renovation may be necessary to replace a component which has become unserviceable or undesirable because of deterioration, damage, or change of design. Renovation of ammunition includes such reconditioning, salvage, and destruction of unusable components as may be required.

b. Reconditioning denotes those maintenance and repair activities which do not involve replacement of unserviceable components. It includes such operations as derusting, repainting, restenciling, repair of containers, and superficial repair as removing dents from cartridge cases and straightening bomb fins, etc.

c. Maintenance is an all-inclusive term involving reconditioning and renovation as defined above. More specifically, maintenance is the maintaining of stocks of ammunition, ammunition components, and explosives in serviceable condition for immediate use.

d. Salvage includes operations necessary to disassemble or break down ammunition and ammunition components in order to recover therefrom all materials and components which are or may be serviceable or which may have value as scrap.

208. DESTRUCTION OF UNFIT OR UNSALVAGE AMMUNITION. Ammunition or its components which are unfit for salvage or are unsafe to handle are disposed of by such methods of destruction as detonation, burning, or dumping at sea, as described in chapter 4.

209. AUTHORITY FOR RENOVATION.

a. Renovation of ammunition, ammunition components, and explosives will be undertaken in the Zone of the Interior only upon receipt of specific authority and instructions from the Chief of Ordnance.

b. The Chief of Ordnance issues orders for renovation operations based upon one of the following:

(1) Surveillance reports from an ordnance activity to which ammunition inspectors are assigned, either in the United States or the overseas departments.

(2) Reports of functioning or other tests, either surveillance, acceptance, or special.

(3) Reports from the using services usually originating from ordnance officers assigned to class I, II, or III installations or with command organizations.

(4) Reports of malfunctions and accidents from the using services, submitted in accordance with AR 750-10, which may disclose a desirable engineering change.

210. SAFETY REQUIREMENTS.

a. Renovation should be performed in an isolated area or building specifically designated for that purpose. The quantity of explosives present should be the minimum necessary to carry out the operation. These operations should be carried out in conformity with the quantity-distance requirements of chapter 3, section II, based upon the total quantity at the operation. The number of persons permitted at or near the operations should be kept to a minimum. The area or buildings should be free of loose explosives, waste paper, and other combustible material. All work will be performed under the direct and competent supervision of experienced personnel.

b. Renovation operations are hazardous and require a thorough knowledge of the activities involved, the hazards to be guarded against, and the precautionary methods necessary for greatest protection to personnel and property. The equipment used must be designed with this in mind and, in many instances, operations must be conducted in workrooms barricaded for the protection of personnel and property in the vicinity of the hazardous operations. Barricades may be of three general types: reinforced concrete, metal, or earth, or any acceptable combination thereof. The height and thickness of the barricade are governed by the renovation requirements. The decision as to the number and type of operations to be conducted behind a barricade should be based on the hazards involved, and the barricade, equipment, and tools to be used should be designed to make the best and most efficient use of the protection afforded by the installation.

211. SAFETY REGULATIONS FOR MAINTENANCE AND SALVAGE OF EXPLOSIVES OR AMMUNITION.

a. Ammunition or explosives shall not be renovated or salvaged within a magazine where other ammunition or explosives are stored. These operations shall not be carried on within the magazine area unless the site, empty magazine, buildings, or cars in which the work is done are devoted exclusively to such work, and are specifically approved by the Chief of Ordnance. Such operations may be carried out in an empty magazine or in the open at intraplant quantity-distance requirements, but in no case at less than 100 feet from the nearest location of explosives.

b. The quantity of explosives or ammunition involved or present in any operation at one time in one location shall be limited to the minimum quantity necessary to carry out the operation, thus:

(1) Black powder, 100 pounds.

(2) Separate-loading propelling charges—1 open container, and four closed containers.

(3) High explosives are limited to one open container of 100 pounds and four closed containers.

(4) Smokeless powder limits shall be one open container and nine closed containers.

c. Hazardous operations, such as those involving the removal of boosters from shells, and the disassembly of fuzes and grenades, shall be barricaded to reduce operating hazards. Disassembly of ammuni-

tion and bombs and other similar disassembly operations [illegible] performed behind an adequate barricade [illegible]

(1) Disassembly of loaded [illegible] primers and blank ammunition.

(2) Removal of boosters and fuzes [illegible] base plugs from loaded projectiles and [illegible] boosters from [illegible] shells.

d. The following and very similar disassembling operations [illegible] be performed without a barricade provided the assembly [illegible] usual and the ordinary equipment [illegible] assembly are sufficient to accomplish the [illegible] application of undue force. Care must be taken to [illegible] the surfaces to be separated are not corroded, contain no [illegible] or other binding agents, and are not sealed with metallic [illegible] undue force is necessary, these operations must be accomplished behind a barricade.

(1) Removal of loaded fuzes and fuze well cups and [illegible] cartridges from loaded shells, 60-mm and 81-mm [illegible] assembly of projectiles and cartridge cases [illegible] the removal of set screws from loaded projectiles.

(2) When stake punch marks must be removed with [illegible] equipment, the equipment must be provided with a positive stop to prevent the contact of the drill with the fuze or booster parts [illegible] the explosives in the shell or its contents.

(3) The removal of hand grenade fuzes from loaded grenades must be performed immediately in front of a suitable protective tank equipped with an effective baffle, into which the grenade can be deposited should a premature ignition of the firing medium occur.

e. When soldering operations are performed upon metal containers, precautions shall be taken to insure that they contain no loose grains of powder or explosives dust.

f. All salvage components must be kept separate until disposed of in accordance with Army Regulations or directions of the Chief of Ordnance.

212. EQUIPMENT FOR BARRICADES.

a. Normally the equipment required for barricaded operations consists of a suitable barricade, holding devices, operating device, means of following the operation, and method of safely transmitting power required for the operation.

(1) A suitable barricade is one that will afford the necessary protection to personnel and property. The location of the barricade should be such that it will equal or exceed the minimum safety dis-

tances required by the class and quantity of explosive involved, as shown in paragraph 172.

(2) A suitable holding device located to the rear of the barricade, may consist of some form of a vise or jig on either a fixed or an adjustable base, placed in such a manner as to hold the item in a centered position so as to permit the proper application of the operating device.

(3) A suitable operating lever may be a wrench or other tool designed to fit the item for the work to be performed.

(4) A suitable means for observation may be furnished by a mirror or series of mirrors located so as to keep the personnel at a safe distance from the operation.

(5) A suitable method of transmitting power to the operating device normally consists of a shaft extending through the barricade and should have a positive stop on the operating side to prevent its being blown forward through the wall in event of an explosion. Personnel should not be exposed in a direct line with a shaft which extends through a barricade.

213. TOOLS AND SUPPLIES. Tools and supplies for ammunition renovation are listed in ORD 10 SNL N-500-GA and described in TM 9-1905. Other tools and equipment that have to be designed should meet strength requirements and guard against the introduction of chemical, mechanical, or electric hazards over and above the normal hazard of the ammunition and explosives involved. When exposed explosives are involved, the use of safety tools and equipment, which may be made of nonsparking metals, wood, or fiber, is required. The use of certain types of nonsparking tools must be judicious, however, because certain types of nonsparking metals may form sensitive salt compounds with certain types of explosives; for example, the use of any copper-bearing metal with explosives containing nitrates.

214. PLANNING OPERATIONS.

a. In planning normal operations, the sequence of operations should be considered in four separate phases (not considering movement to and from storage):

(1) Disassembly group. Removing packing materials, and disassembling ammunition preparatory to renovation.

(2) Reassembly group. All preparation for and proper reassembly of the item.

(3) Finish group. All necessary reconditioning and returning of the items to their packages, with necessary package marking and repair.

(4) Disposal group. Disposing of all unserviceable or unusable component parts, waste explosives, etc., that may accumulate during renovation operations.

Section VIII

PRECAUTIONS FOR FIRING

214. GENERAL. Specifications, standards, and limits of precision are prescribed for the manufacture and preparation of ammunition. In spite of this, inherent limitations exist and malfunctions of ammunition may occur. The immediate problem is to prevent the occurrence of malfunctions wherever possible, to minimize the effect when they do occur, and to avert, through experience, similar malfunctions in the future. The general safety precautions, chapter 3, section I, should be observed wherever applicable. The specific regulations and precautions for the use of each type of ammunition given in this section and in chapter 2 will be observed.

215. GENERAL PRECAUTIONS BEFORE FIRING

a. **Status of ammunition lots.** A check should be made to determine the status of the lot of ammunition intended for its use. Ammunition should not be fired if the lot number is not positively known. If defects which may affect the safety and functioning of the ammunition are found in a lot graded as suitable for firing, a prompt report of the condition will be submitted to the service command or department ordnance officer. Firing of that lot of ammunition will be suspended pending instructions from the proper ordnance officer. If malfunctioning occurs during firing, a prompt report on the ammunition lot will be made as prescribed in AR 750-10.

b. **Alterations and substitutions.** Any alteration of loaded ammunition except in accordance with specific instructions from the Chief of Ordnance is hazardous and therefore prohibited. Serious and fatal accidents have resulted from substitution of propelling charges, fuzes, primers, and projectiles, and from the local preparation and loading of practice ammunition, including grenades, pyrotechnics, etc.

c. **Placing ammunition.** All ammunition at the firing point will be so placed as to minimize the possibility of ignition, explosion, or detonation in case of accident at the gun position. It should be in a dry place and protected from the direct rays of the sun by tarpaulin or other covering. There should be ample circulation of air through and on all sides of the stack. Erratic ranges and dangerously high pressures may result from overheated ammunition. White-phosphorus shell will be stacked (preferably with the base of the projectile down, although if the temperature is not expected to exceed 105° F, this precaution is not necessary) in a space cleared of all combustible material, away from personnel and other ammunition. All components in the field should be stored separately and in small amounts to minimize danger from accidental burning of powder or detonation of projectiles, fuzes, and primers. Chemical ammunition is stored away from other types of ammunition.

d. **Safety zones.** Data for definition of safety zones for troops in firing small arms, artillery weapons, and chemical-warfare weapons will be found in AR 750-10.

e. **Smoking.** Smoking by anyone handling, or in the vicinity of, explosives or ammunition is prohibited.

f. **Lights.** Use of any lights other than approved lanterns or flashlights in the vicinity of explosives or ammunition is prohibited.

g. **Handling.** *Care should be taken not to drop projectiles, powder containers, or fuze or primer containers. Projectiles should not be allowed to strike together. All safety precautions for handling ammunition given in Technical Manuals and in this manual will be rigidly observed.*

h. **Packings.** Moisture-resistant seals of packed ammunition should not be broken until the ammunition is ready to be used. Rounds should not be withdrawn from containers until they are ready to be fired unless the ammunition is to be loaded directly into the caisson. Safety devices on fuzes will be removed just before firing and at no other time. Components of rounds prepared for firing but not fired will be returned to their original condition and packings and appropriately marked and resealed. Such components will be used first in subsequent firings in order that stocks of opened packings may be kept at a minimum.

i. **Cleanliness.** The complete round or each component should be inspected by a member of the gun crew for burs, dents, gravel, dirt, grease, and other materials before loading into the gun. A cloth should be kept nearby for wiping off grease, dirt, and foreign matter. Ammunition must be clean and free from dents, which will interfere with proper seating of the round, before it is placed in the weapon.

217. GENERAL PRECAUTIONS DURING AND AFTER FIRING.

a. **Defects and malfunctionings.** AR 750-10 provides that all officers having charge of firing must make a report to the local ordnance officer of any ordnance materiel issued to the troops which malfunctions in firing or reveals defects either in firing or in storage, including such malfunctions and defects as are noted in target-practice reports. It is the duty of the local ordnance officer to investigate all cases of malfunctioning and defects observed by him or reported to him, and to report serious cases to the Chief of Ordnance through the service command ordnance officer. Whenever an accident occurs which results in injury to personnel or damage to materiel, the lot of ammunition will be suspended from use and an immediate report will be made directly to the Chief of Ordnance by the ordnance

officer under whose supervision the materiel is maintained or issued. One copy of this report will be sent to the service command ordnance officer. Accidents of a serious or potentially serious nature require a report by the quickest means of communication available. Insofar as practicable all evidence will be preserved and not be disturbed until the arrival of an investigating officer.

b. **Protection of personnel.** AR 750-10 gives the regulations and details for protection of persons in the vicinity of the firing point. Any individual in the military service who observes a condition which makes firing obviously unsafe will immediately command "CEASE FIRING." If at a distance from the unit firing, he will make the prescribed signal to halt firing. When chemical ammunition other than smoke is fired, all persons will be provided with gas masks. Consult AR 750-10 for regulations governing the use of service ammunition for training purposes.

c. **Firing through trees.** When firing ammunition from a mask of trees, a premature burst may result if a fired shell or shrapnel strikes the branch of a tree. The striking of even a twig by a shell fitted with a time fuze may derange the setting or deform the time ring and cause a premature burst.

d. **Duds.** A dud is a discharged but unexploded bomb, projectile, or grenade. It may result from defects in the fuze, booster, or charge; from the unscrewing of fuzes in flight; or from the character of the ground at the point of impact. Whenever a dud can be readily located and examined without moving it, an effort should be made to determine the cause of the failure. A dud is a source of danger and if improperly handled may explode and injure personnel. A comparatively slight blow or disturbance may cause it to explode. Duds should be destroyed in place (for methods of destroying see chapter 4).

218. SMALL-ARMS AMMUNITION.

a. **Inspection.** Small-arms ammunition will be examined before issue. The procedure for examination and the defects to look for are described in TM 9-1990. WDSS 9-AMM-4 contains essential information concerning the grading of small-arms ammunition and the disposition of fired components and unserviceable rounds in accordance with AR 775-10. Lots having more than 5 percent of defective cartridges will be subjected to 100-percent inspection, defective rounds culled out, the serviceable cartridges repacked prior to issue, and report made to the Chief of Ordnance. Normally, small-arms ammunition will have no visual defects unless it has been stored for a considerable period; ammunition with less than 5 percent visibly defective rounds may be issued without 100-percent inspection. If 20 percent or more are defective, the lot is withdrawn from service and held for disposition. The post ordnance officer should see that the troops are instructed as to the kinds of visible defects which can be readily detected and the correct manner in which to cull ammunition. Particular attention should be paid to incipient cracks which are not easily detected unless the thumb is pressed against the bullet, thus exposing the crack in the cartridge case. Defective cartridges will be considered as grade 3 ammunition.

b. Identification. Since different types of small-arms ammunition are of similar appearance, the kind of ammunition being issued will be strictly checked from the markings on the packing.

c. Firing blank cartridges. Blank cartridges should not be fired at a representative enemy at distances less than 20 yards, as the wad or paper cup may fail to break up.

d. Misfires and hangfires.

(1) For procedure in the event of an apparent misfire, see chapter 2, section I.

(2) When a hangfire occurs, in any lot, its use should be suspended and a report will be made as prescribed in AR 750-10 to the post ordnance officer, giving the number of the lot involved. The ammunition lot thus affected will be withdrawn and replaced by serviceable ammunition.

e. Lodged bullets. When a bullet lodges in the bore of a rifle, pistol, or machine gun, it should be removed by the application of pressure from the muzzle end of the weapon. *To attempt to shoot the bullet out with another cartridge is extremely dangerous and therefore prohibited.*

f. Defective rounds. Dented cartridges, cartridges with loose bullets, or otherwise defective rounds should not be fired.

g. Misfires in blank firing. Misfires in which the primer explodes but fails to ignite the powder charge have proved dangerous in firing automatic arms with blank-firing attachments. Some of the powder is blown into the bore and becomes lodged in the blank-firing attachments. A series of such rounds will cause an accumulation of powder sufficient to result in serious damage when ignited by a normal cartridge. When misfires in excess of 5 percent occur in firing blank cartridges, the firing of that lot of ammunition will be suspended and reported to the Chief of Ordnance.

h. Armor-piercing ammunition. The use of armor-piercing cartridges is prohibited in demonstrations in which tanks take part. When using armor-piercing ammunition, the cores of bullets which fail to penetrate will rebound. The radius of rebound depends on several factors but may be estimated as a maximum of 100 yards for caliber .30 and 200 yards for caliber .50 armor-piercing ammunition.

i. Protection of ammunition. After a container of ammunition is opened and cartridges issued, each man should take care of his own ammunition. The primer should be protected from blows by sharp instruments, as such a blow might explode the cartridge.

j. Use of oil or grease. The use of oil or grease on cartridges is prohibited. These agents cause injurious abrasives to collect in automatic weapons and produce excessive and hazardous pressures on the rifle bolts when nonautomatic rifles are fired. NOTE: *This restriction is not applicable to 20-mm ammunition.*

219. ARTILLERY AMMUNITION.

a. Examination. Before firing, representative samples from each lot of ammunition should be examined for visible defects such as exudation, corroded fuzes, looseness of projectiles in cartridge cases, damaged rotating bands, and excessive moisture and dampness, etc. If these defects are likely to cause difficulty when the fuze is set or the round is loaded into the gun, or question exists as to the safety and functioning of the ammunition, it should not be used until it has been examined by the service command ordnance officer or his assistants. Care should be used in condemning ammunition from use, as shell which are exuding slightly can be made serviceable as prescribed in War Department Supply Bulletins. Often fuzes which are only slightly corroded or discolored are serviceable and can be used.

b. Packings. If the ammunition is packed in individual tin or fiber containers, the containers should be opened by means of the tear strip provided; the round should not be withdrawn from the container until it is to be fired unless the ammunition is loaded directly into the caisson. All powder charges except the charge to be served to the piece for the next succeeding round will be kept in their containers.

c. Placing of ammunition. At the firing point, ammunition which is not carried in caissons should be located to the left of the caisson, and not directly to the rear of the gun. It should be protected from moisture, dampness, and the direct rays of the sun by a tarpaulin so placed that air can circulate through the pile.

d. Propelling charges.

(1) PREMATURE IGNITION. The powder charge for a round will not be brought near the breech of the gun until the preceding round has been fired, the powder chamber carefully sponged with a wet sponge or cleared of any possible smoldering remains by use of the gas ejectors, and the face of the mushroom head has been wiped.

(2) FLAREBACKS. When the breechblock is withdrawn, the gases remaining in the bore sometimes pass to the rear and ignite upon striking the air, regardless of the direction of the wind. Flames of

varying length and intensity result. Precautions must be taken to prevent the flame from reaching a new propelling charge, as well as to prevent serious burns to the breech detail.

(3) BLENDING. Propelling charges will be fired as received. Blending will not be resorted to except in special cases where the necessity therefor has been approved by the Chief of Ordnance, who will furnish the necessary instructions.

(4) ERRATIC AND EXCESSIVE PRESSURES. Erratic pressures or ranges may be due to deteriorating propelling charges, improper ignition of the propelling charges, defective or loose rotating bands, and, in the case of separate-loading ammunition, improper wrapping or lacing of the charge. Excessive pressures are likely to develop if the diameter of the propelling charge is altered so as to prevent the projection of the flame from the igniter to the front of the powder charge. For further information, see AR 750-10. All powder lots giving excess pressures should be immediately suspended from use, pending instructions from the Chief of Ordnance.

(5) MAXIMUM RANGES. The term "supercharge" is purposely used in referring to the propelling charge required to give maximum range. It cannot be too strongly emphasized that the "normal charge" should be used always within the ranges obtainable, and that the use of supercharges must be avoided except where maximum ranges are necessary. If this is not complied with, excessive wear of the guns will result. With multisection propelling charges, the complete charge is used when supercharge is desired; only the base section and such lower zone increments as may be required are used in the lower and intermediate ranges. Where the charge is of base and increment type, only the base charge is used when the normal charge is desired.

(6) IGNITERS.

(a) When loading the separate-loading propelling charge into the gun, be sure that an igniter is always on the end of the charge toward the breech. The cloth used for assembling igniters is dyed red and indicates clearly the end which should be at the rear of the chamber. The red dye also indicates that the igniter contains black powder. Undyed igniter cloth has been used, however, for some propelling charges now in the service. In this case the igniter end can be identified by the quilting used to hold the black powder in position and by the words "IGNITING POWDER" stenciled on the igniter.

(b) Propelling charges should not be placed in the gun with the igniter fastened to them by safety pins. Before firing, the safety pins should be removed and the igniter pad attached to the charge by sewing, the stitching being caught in at least three places, 120 degrees apart.

(c) It is the practice to pack one igniter in each cartridge-storage case. Surplus igniters remaining after firing should be destroyed in accordance with chapter 4.

(7) TAGS AND PROTECTOR CAPS. Igniter protector caps and data tags will be removed from propelling charges before loading into the gun.

e. Difficulties in loading or extracting ammunition.

(1) Difficulties in loading or extracting ammunition may be due to dented or bulged cartridge cases, or to foreign material in the chamber or bore of the gun. When the cartridge case is hard to extract, an inspection of the chamber should be made to determine whether the chamber is fouled, scored, or pitted. If it is fouled, it can be readily cleaned; but if it is pitted or scored, a report should be made to the post ordnance officer. The use of a tool to strike the base of a cartridge case to chamber rounds is prohibited. Personnel should be protected in case a round is partially chambered and the breechblock is completely closed. In a heated chamber, ignition of the propellent powder may occur.

(2) If a projectile cannot be readily extracted from the gun or if a projectile becomes separated from the cartridge case when the breech is opened, it should be fired out, if possible, particularly if the cartridge case will slip over the base of the projectile and will chamber in the normal position. If the cartridge case will not slip over the base of the projectile, the cartridge case should be shortened the necessary minimum amount; when this is done, a reduced charge should be used (approximately half of a normal charge) because of the reduced obturation, particular care being taken that the point of impact of the projectile is such as not to endanger personnel or property. If this is not possible, the projectile should be removed under the direct supervision of an officer, using a rammer which bears only on the projectile and provides for clearance around the fuze.

(3) If a rammer is used, extreme care should be exercised to prevent any force from being applied against the fuze. The Edwards rammer, designated as RAMMER, unloading, M1, is provided for this purpose for use with 75-mm point-fuzed projectiles (fig. 163).

(4) The removal of the projectile, whether by firing out or by ramming, should be done under the direct supervision of an officer.

f. Misfires. When a misfire occurs, the following precautions will be observed:

(1) FIXED OR SEMIFIXED AMMUNITION. Two attempts will be made to fire, except in the case of guns which cannot be recocked, without opening the breech. Upon failure to fire for 30 seconds, the misfired round will be removed. If it is not possible to remove

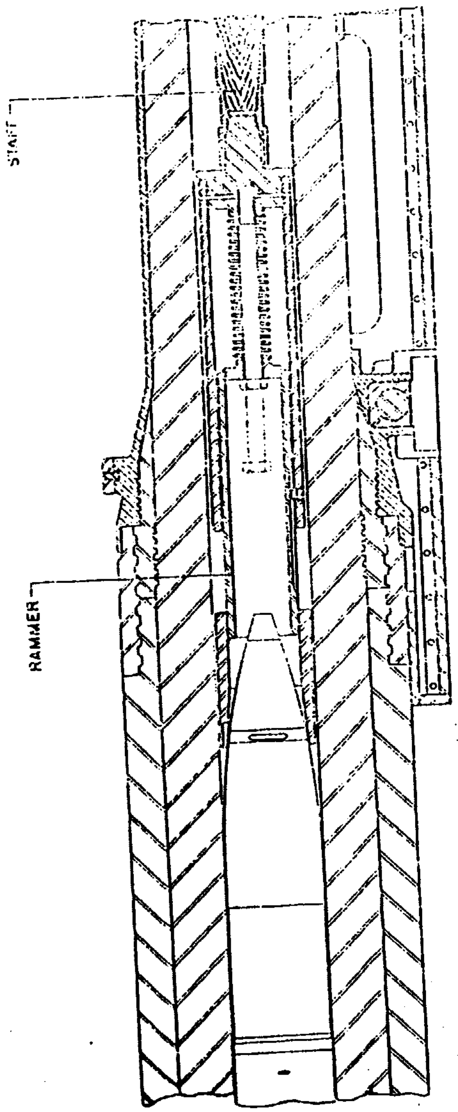


Figure 163 — Rammer M1 for 75-mm Guns — Method of Removing Shell from Gun

the round from a hot tube within 45 seconds after the original misfire, water should be played on the barrel until it is cool. The safest time to remove a misfired round of fixed ammunition is between 30 and 45 seconds after its occurrence.

(2) SEPARATE-LOADING AMMUNITION.

(*a*) Two attempts will be made to fire the primer before it may be removed. If the primer is heard to fire, a minimum of 60 seconds will be allowed before the breech may be opened and the faulty charge removed. The faulty charge must be stored separately from other charges.

(*b*) If the primer is not heard to fire, two more attempts to fire will be made. Then proceed as follows:

1. If the primer can be removed by a person standing clear of the path of recoil, after 2 minutes have elapsed, the primer may be removed and a new one inserted. If the second primer fails, 10 minutes should be allowed to pass and then the breech may be opened.

2. If the primer cannot be removed safely as described above, no attempt will be made to open the breech or replace the primer for 10 minutes.

(*c*) Misfire primers should be handled carefully and disposed of quickly, owing to the chance of a primer hangfire. Further information will be found in AR 750-10 and the Technical Manuals and Field Manuals pertaining to the piece.

g. Fuzes.

(1) *Extreme care must be taken in handling and assembling fuzes to shell or bombs. All fuzes must be treated as delicate mechanisms. The forces which arm a fuze on firing a weapon can be simulated by rolling or dropping, and a fuze so armed may be functioned by the impact of a blow or by dropping.*

(2) In the assembly of fuzes and projectiles, the fuze body, threads, adapter, and fuze cavity must be inspected to insure that grit, grease, or other foreign material is not present. This is necessary for proper seating of the fuze without the use of excessive force. Cleaning of the fuze cavity should be accomplished with a piece of cloth and a small stick which can be inserted into the cavity. Fuze-hole lifting plugs should not be removed except for inspection or when the fuze is about to be inserted.

(3) When ammunition or projectiles are issued fuzed, no attempt will be made to remove the fuzes without specific authority and instructions from the Chief of Ordnance.

(4) Fuzes will not be altered. Any attempt to alter or disassemble fuzes in the field is dangerous and is prohibited except under specific direction of the Chief of Ordnance. The only authorized assembling or disassembly operations are screwing the fuze into the

CHAPTER 4

DESTRUCTION OF AMMUNITION IN ZONE OF THE INTERIOR

224. GENERAL.

a. General.

(1) The instructions set forth in this section are for destroying limited quantities of explosives and ammunition. The term "limited" is defined in subparagraph d, below. When larger quantities are to be destroyed or the instructions set forth cannot be complied with, special instructions will be furnished by the Chief of Ordnance.

(2) Unserviceable ammunition, ammunition components, and explosives which constitute a hazard, cannot be salvaged, or are unfit for their intended purpose and cannot be used to advantage for any other purpose should be destroyed in accordance with existing regulations. As a general rule at Class I, II, or III installation, the only ammunition items requiring destruction are obsolete or deteriorated ammunition (which may be considered together) and duds.

(3) Lumber which has been exposed to explosives and which cannot be readily decontaminated should be destroyed by burning only under conditions approved for safety. Examples of such lumber are wooden sections of tanks, vats, hoods, pipe lines, etc., in which hazardous material is impregnated. However, if wood has been exposed to explosive material to a limited extent, it may be possible to decontaminate it completely by washing or steaming.

b. Responsibility and procedure. Prior to destruction, an Ammunition Condition Report (O.O. Form 517—formerly O.O. 7235) will be submitted to the Chief of Ordnance in order that the disposition may be approved. This report will be prepared in accordance with instructions on the reverse side of the form. An exception is deteriorated explosives or ammunition which is found to be immediately dangerous to life or property; in such instances, disposition may be made by order of the local commanding officer. The responsibility for disposition is a function of the inspector; the responsibility for destruction is a function of the post ordnance officer. Where local break-down of unserviceable ammunition is ordered, technical instructions for the work will be furnished by the Chief of Ordnance.

c. Methods. Destruction of explosive material will be accomplished by burning, exploding, or dumping at sea, as specified below. Burying of explosives or ammunition or dumping them into waste places, pits, wells, marshes, shallow streams, or inland waterways is *absolutely prohibited;* except that loose black powder (par. 227) may be disposed of by dumping into a stream or body of water. Methods for destruction are generally based on the number of units to be destroyed, the size and nature of each unit, the facilities available, and the topography of the land.

d. Quantity of ammunition and explosives. By a "limited" quantity of ammunition and explosives, this section refers to the number of unexploded shell and other ammunition normally found on a target range or in the field as an accumulation from firings or other peacetime maneuvers. Larger quantities, generally referring to ammunition resulting from deterioration in storage or from obsolescence, are to be destroyed according to specific instructions from the Chief of Ordnance.

e. Materials used in destroying by explosion. Charges of ½-pound blocks of TNT or sticks of dynamite are used. These are set off either by time fuse (safety fuse) and a blasting cap, or by a magneto and an electric blasting cap. In no case will "instantaneous" fuse be used. For demolition purposes nitrostarch blocks have been authorized as a substitute for TNT blocks. Nitrostarch is a hard dense substance considerably more sensitive to friction and impact than TNT. *The crushing or breaking of the nitrostarch blocks is hazardous.* Dynamite is not to be used in the destruction of duds.

f. Materials used in destroying by fire. Fires used in destroying small ammunition components may be made from scrap lumber, wood, or such material as excelsior. When components to be destroyed are laid on the pile before lighting, the fire will be lit from a distance by means of a train of inflammable material or by a charge of black powder ignited with an electric squib.

g. Specific types. Information dealing with the particular type to be destroyed will be found in the paragraphs following.

h. Demolition methods. For details of methods and procedure of demolition work, consult FM 5-25.

225. DUMPING AT SEA.

a. When burning or detonation of explosives or ammunition is impractical, dumping at sea at depths not less than 900 feet and not less than 10 miles from shore is permitted. Before disposal, by dumping in the sea, of any ammunition, every effort will be made to salvage it for further use or reclamation of component parts. Dumping in the sea will, in every instance, be done only upon War Department order.

b. Navy, Coast Guard, and port authorities must be consulted and their regulations regarding transfer and disposal of material of this nature must be observed. Ammunition items must be removed from containers before being dumped overboard. The location selected for dumping should be appreciably deeper than surrounding locations to preclude the possibility of ammunition being washed toward the shore by tidal action.

c. In transit, the boat or barge will display a large red flag at least 10 feet above the deck and a competent person will be constantly on the alert to warn approaching craft of danger. When necessary, a War Department representative, who is familiar with the hazards involved in handling ammunition, will accompany commercial vessels contracted to dump such material in the capacity of a safety adviser.

226. SAFETY PRECAUTIONS.

a. **General.** Safety is the major consideration in destroying ammunition and explosives. It is highly advisable to test all safety devices beforehand by subjecting them to the severest test they may be called upon to withstand, provided that such test is reasonable and practicable. Only after safety requirements have been met should salvage and economy be considered. It may be necessary to improvise apparatus to accomplish the desired results, and it is essential that the destruction procedure be analyzed and planned in detail for compliance with the general safety precautions in chapter 3, section I. The general safety precautions that must always be complied with in destroying ammunition are described below.

b. **Selection of site.**

(1) FOR DESTRUCTION BY BURNING. The selection of a site for destruction of explosives by burning should be based on the principle of obtaining the maximum practicable distance from all magazines, inhabited buildings, operating buildings, public highways, and railways. Consideration should be given to the direction of prevailing winds. Wherever possible, natural barricades should be utilized between the burning site and operating buildings and magazines. The burning site should be approximately inhabited-building distances from all structures and public thoroughfares.

(2) FOR DESTRUCTION BY DETONATION. The selection of a site for destruction of ammunition by detonation is based on the same principles as in step (1), above. Such a site should be 3,600 feet from public highways, public railways, inhabited buildings, magazines, and operating buildings. Where this distance cannot be obtained, a pit or trench should be used to limit the range of missiles. The 3,600-foot limitation does not apply where substantially constructed destruction chambers are used. Pits will not be required when the destruction takes place on an artillery range or similar site where a cover of earth 2 feet thick should be used to limit the range of fragments. Combustible rubbish should be destroyed at a location removed from those places where explosives and explosive-contaminated material are destroyed. Where limited space does not permit separate burning grounds, a part of the explosive destruction may be reserved for burning rubbish, provided the two areas are not operated simultaneously. Such an area should be enclosed by a substantial wire mesh, not over ½-inch mesh.

c. **Maintenance of grounds.** All dry grass, leaves, and other inflammable materials within a radius of 200 feet from the point of destruction will be removed. Fire-fighting facilities for combating grass fires should be kept readily available and, if practicable, the ground at the point of destruction should be wet down with water at the close of each day's operations. The use of concrete mats for burning or detonation is not permitted.

d. **Protection for personnel.** Personnel engaged in demolition work should always have ample time to reach shelter affording substantial overhead cover and splinter-proof protection. The signal for detonation should be given by the individual setting the blastings, and only after all personnel in the vicinity are protected by substantial cover or have reached a safe distance. If an electric blasting machine is used, the wires will not be connected to the terminals until all persons have reached cover and the person in charge of the blasting is assured that the area is properly cleared of all personnel. Dependent upon local conditions, temporary or permanent barricades will be provided and safety distances will be observed by all persons.

e. **Safety distance requirements for preparation of primers and demolition charges.** It is extremely important that personnel take adequate precautions to prevent accidental explosions while preparing primers for demolition activities. In addition to the general safety precautions currently in force, the following safety rules for the preparation of primers and demolition charges *will be strictly observed.*

(1) Test-burning of time fuse (safety fuse), for determination of rate of burning of the roll, will be done at a minimum safety distance of 25 feet from exposed blasting caps or explosives in the direction toward which the air current is moving.

(2) Cutting square across end of time fuse (safety fuse), remove and discard 2 or 3 inches of fuse from each roll.

(3) Cut off and test a 1-foot length from each roll for determination of burning time. *All fuse in the same roll should burn at a uniform rate, though rate of burning may vary from approximately 30 to 45 seconds per foot in different rolls.*

(4) The supply of blasting caps for the required operation will be at minimum of 25 feet from the supply of explosives.

(5) The preparation of nonelectric primers will be performed not less than 25 feet from the supply of blasting caps or explosives.

(6) Cut sufficient time fuse (safety fuse) to permit firer to reach a place of safety before the charge explodes.

(7) Select one nonelectric blasting cap, hold it open end down,

and shake *gently* to remove dirt or other foreign matter. Hold the desired length of time fuse (safety fuse) vertical and gently slip the cap down over the fuse until the explosive is in contact with the end of the fuse. If the fuse appears too large to enter the blasting cap easily, the end to enter the cap may be rolled between the fingers. CAUTION: *Do not use force.*

(8) When the fuse is properly seated within the cap, place a standard-type cap crimper over the cap at the fuse end; hold by the fuse and crimp cap to fuse.

(9) No more than six blasting caps will be permitted at the site selected for preparation of primers at any one time.

(10) The priming of explosives will be performed at a distance of not less than 25 feet from the site of any other permissible storage or operation point involved in connection with the preparation of primers and demolition charges.

(11) Not more than one primed charge of explosives will be permitted at any site at any one time.

(12) The preparation of primers and the priming of explosives will not be performed in advance of requirements for use of same, in view of possible atmospheric effects.

(13) Bring to the site of the operation only sufficient explosives to meet the requirement of the operation involved.

f. Removal from containers. Explosives or ammunition to be destroyed by burning will be removed from containers, as any attempt to burn explosives or ammunition under even slight confinement may result in an explosion or detonation.

g. Determining quantity to be destroyed. The quantity of material to be destroyed at one time will depend upon local conditions. This quantity will be carefully determined by starting with a limited number and then gradually increasing that number until the maximum which can be destroyed without damage to surrounding property or causing disturbance to civilian areas is determined. The responsible individual will make sure before he gives the signal for detonation that there is no unauthorized person in the danger area and that all authorized persons are protected by adequate distance and cover.

h. Collection of unexploded ammunition. As some types of ammunition are comparatively difficult to explode, a search of the surrounding grounds should be made after each blast and any material which has been thrown from the pit and not detonated should be collected and included with the next charge to be destroyed.

i. Segregation of material awaiting destruction. Explosives or ammunition awaiting destruction will not be piled within 200 feet of the point of destruction and will be protected from grass fires, burning embers, and flying fragments. All dry grass, leaves, and other inflammable material will be removed from the area within a radius of 50 feet of the pile.

j. Caution against re-ignition. In repeating burning operations, care will be taken to guard against material being ignited from burning residue or heat in the ground.

k. Improvising. The use of improvised methods for exploding blasting caps is prohibited.

l. Misfires. In case of a misfire, personnel will not approach the pit, trench, or point of detonation until a period of 30 minutes has elapsed.

m. Use of trained personnel. Destruction of ammunition will never be attempted by inexperienced or untrained personnel. The number of personnel engaged in such operations will be kept at a minimum consistent with safety, but no person will be permitted to work alone.

n. Guarding demolition area. Guards, safety signals, and warning signs will be used as required to keep unauthorized personnel from danger areas during destruction operations.

o. Additional instructions. In the absence of specific regulations or information covering any phase of the destruction of explosive material, instructions will be requested from the Chief of Ordnance.

227. BULK EXPLOSIVES.

a. Black powder. The safest method of destroying black powder is to dump it in a stream or body of water; if no suitable body of water is convenient, it may be burned. Only tools of wood or nonsparking metal will be used in opening the containers. The contents of one container only will be burned at one time provided that quantity does not exceed 50 pounds. The powder must be removed from the container and spread out on the ground in a train about 2 inches wide, care being taken that no part of the train parallels another part except at a distance of more than 10 feet. A train of inflammable material, such as excelsior, about 25 feet long and extending to windward must be used to ignite the powder, as the resulting flare of explosion is so quick that there will be no opportunity to withdraw. The emptied containers will be thoroughly washed on the inside with water, as serious explosions have occurred with supposedly empty black-powder cans. Safety precautions, particularly those in paragraph 226, should be observed. Wet black powder on drying may resume its explosive properties.

b. TNT, explosive D, and tetryl will be destroyed by burning. They must not be dumped into water, as they poison it. The explosive to be burned will be removed from containers and spread in a thin layer, not more than 3 or 4 inches thick, on another layer of inflammable material, such as excelsior. A train of inflammable material will be used to ignite the explosive. Safety precautions in paragraph 226 should be observed. High explosives should not be burned in lump form. If explosives must be burned in lump form, the quantities should be less than stipulated below for loose explosives, and an explosion may occur. Instances are on record of explosives below (which in most instances burn), detonating while being burned. The maximum amounts of loose high explosives which may be burned at one time shall be limited as follows:

(1) DNT, TNT, explosive D—500 pounds.

(2) Pentolite, tetrytol—250 pounds.

(3) Tetryl, composition A, B, and C, RDX, haleite—50 pounds.

c. **Smokeless powder.** Small quantities of smokeless powder (a few boxes) up to 500 pounds may be destroyed with safety if the powder is removed from the containers and spread out on bare ground in a train of limited width and thickness dependent upon the granulation of the powder. A train of inflammable material about 25 feet long on the windward side, should be used to ignite the powder; this allows personnel sufficient time to get away from the intense heat which is generated when smokeless powder burns. Safety precautions in paragraph 226 should be observed.

d. **Dynamite.** Not more than 100 pounds are to be destroyed by burning at one time. To destroy by burning, dynamite cartridges, except frozen cartridges, should be slit lengthwise into halves with an ordinary knife; knives with closing blades should not be used. The slit cartridges are placed in a single layer, not greater in width than the length of one cartridge, on hay, excelsior, or other combustible material. The combustible train should be of sufficient length to allow personnel to reach cover or a safe distance before the dynamite begins to burn. The dynamite containers should be burned at the same time. Dynamite awaiting destruction should be shielded from the direct rays of the sun. Frozen cartridges shall be carefully thawed, in accordance with instructions contained in FM 5-25, prior to burning.

e. **Other explosives.** If it is necessary to destroy other explosives, such as mercury fulminate, lead azide, picric acid, etc., special instructions will be requested from the Chief of Ordnance.

228. SEPARATE-LOADING PROPELLING CHARGES. Extreme precautions will be taken against sparks. The smokeless powder charges will be removed to the burning ground before being opened. There the powder will be removed from the bag by cutting one of the seams, care being taken not to disturb the black-powder igniting charge. The empty bag and igniter should be immediately and completely submerged in water and the igniter cut open under water. The smokeless powder will be burned as described in paragraph 227 c. The igniter and cartridge bags, after having been thoroughly soaked in water for at least 72 hours, should be removed and allowed to dry in the open; they may then be burned in a pit or trench. Soaking in water is absolutely necessary because the confinement of the black powder by the powder bag, slight as it may be, is sufficient to cause explosion and projection of the burning bags and igniters to distances of 200 feet or more. Bags and igniters awaiting destruction by fire must be kept in a securely closed container. It is permissible, when practicable, to destroy bags and igniters by dumping them in a body of water after the propellent powder has been removed and the various sections of the quilted igniter are cut open while the bag and igniter are still submerged in water. This cutting is necessary to release air trapped in the quilted igniter sections, which would cause the bags and igniters to float on top of the water.

229. ARTILLERY SHELL.

a. The following general instructions for destroying artillery shell by detonation also apply to bombs, mortar shell, rocket shell separated from their motors, and other relatively large components containing high explosive. However, it must be kept in mind that bombs, mortar shell, rocket shell, and antitank mines are composed of as much as 60 percent by weight of explosive and have relatively thin walls, as compared with the 10 to 15 percent of explosive and the relatively heavy walls of artillery shell. Therefore, the number of units of bombs, mortar shell, rocket shell, and mines destroyed in one operation should be reduced accordingly. Shaped charges require extreme care in destruction and should be accomplished in small quantities or singly. Fixed shell and rocket shell (heads) will be disassembled from complete rounds and destroyed in the same manner as separate-loading shell (see below). Before undertaking any demolition operation, the proposed procedure will be checked against the safety precautions prescribed in paragraph 226.

b. The following general instructions contemplate the use of a pit or bombproof hut. An artillery range or similar site, when available, may be used. Note especially paragraph 226 b (2).

c. The projectile to be destroyed will be placed on its side in a trench or pit about 4 feet deep. The number of TNT blocks (or their equivalent) specified in the following table will be placed in contact with the side of the projectile and held in position by earth packed around the projectile. The TNT block is placed on its side; if two blocks are used, one is placed on top of the other. If three blocks are used, two are placed close together on the shell and the third on top of these. If five blocks are used, there will be two layers of two blocks each, with a fifth on top. The demolition blocks are

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detonated by means of an electric blasting cap or miner's safety fuse and cap.

DESTRUCTION OF SHELL BY DETONATION

Caliber of Shell To Be Destroyed	No. of ½-pound TNT Blocks or Their Equivalent
37-mm, 57-mm	1
75-mm, 76-mm, 3-inch	2
120-mm, 155-mm, 6-inch	3
8-inch, 240-mm	4
10-inch, 12-inch	5
14-inch, 16-inch	6

d. One end of the required length of time fuse (safety fuse) (par. 226 e) will be cut and inserted in a C of E special blasting cap until it just touches the charge. The cap will then be lightly crimped to the fuse with a fuse crimper or suitable tool, care being taken not to press the fuse too tightly against the fulminate charge of the blasting cap. A No. 8 electric blasting cap with the necessary length of lead wire and a hand exploder may be used instead of the blasting cap with miner's safety fuse. The blasting cap will be placed in the hole drilled in the TNT block (the top block when more than one block is used), and if necessary tied around it to hold it securely in place. In no case should a cap weaker than the ordinary commercial No. 8 blasting cap be used.

e. In case of a misfire, the precaution in paragraph 226 l should be observed. After the blast, comply with paragraph 226 h.

f. Point-fuzed shell fitted with Mark series adapters and boosters can be detonated without the use of TNT blocks. A No. 8 blasting cap securely held in place in the fuze cavity with a small amount of mud packed around the top of the cap will usually insure complete detonation of loaded shell.

230. BLANK AMMUNITION FOR CANNON. Rounds of blank ammunition which have misfired will be destroyed locally under the supervision of a commissioned officer or personnel designated for this purpose by the service command ordnance officer. All precautions for handling black powder, chapter 1, section IV, and for destroying ammunition, paragraphs 226 and 227, should be observed. An extractor (brass) having a wood-screw thread can be used to remove the closing cap and wad; the black powder pellets may be removed by tipping the cartridge case forward and catching them in the hand; and the primer may be removed by means of a press having a hollow guide and/or ram to carry force of possible primer functioning away from the operator. Before removing the primer with a press, be sure that corrosion will not bind the primer and cause the application of too much pressure. Also, be sure to take all possible precautions to see that no powder dust adheres to the primer.

231. BOMBS. Bombs should be destroyed in accordance with paragraph 229. However, bombs have such thin walls and contain so much more explosive than shell of corresponding weight and usually detonate so completely that extreme precautions must be taken to avoid structural damage to buildings and injuries to personnel. The destruction of bombs larger than 100 pounds should not be undertaken without the specific approval of the Chief of Ordnance. Bombs awaiting destruction should be segregated in small piles 100 feet or more apart and at least 300 feet from the detonating pit. Extreme precautions must be taken to protect bombs awaiting destruction against accidental detonation by fire, fragments, or sympathetic detonation.

232. MORTAR SHELL. Mortar shell should be destroyed in accordance with the instructions in paragraph 229. Care will be taken to limit the number destroyed at any one time and to protect shell awaiting destruction from flying fragments.

233. ROCKET SHELL. Rocket shell, which are separated from their motors, should be destroyed in accordance with the instructions in paragraph 229. Care will be taken to limit the number destroyed at one time and to protect shell awaiting destruction from flying fragments. Rockets having motors attached thereto will be destroyed in accordance with instructions from the Chief of Ordnance.

234. PENTOLITE- AND TETRYTOL-FILLED AMMUNITION.

a. Ammunition filled with pentolite or tetrytol have shaped charges. These include high-explosive antitank shell, grenades, and rocket shell, and demolition shaped charges. Extreme care should be observed in destroying this type of ammunition, and the following precautions should be observed:

(1) Only small quantities or single items should be destroyed at one time.

(2) Fragmentation as well as blast effect should be expected and guarded against.

235. SMALL-ARMS AMMUNITION.

a. All unserviceable caliber .22 and shotgun ammunition will be destroyed locally. Ordnance field representatives, within their jurisdiction, are charged with the disposition of all other unserviceable small-arms ammunition and accumulations from firings. Reference to WD SB 9-AMM 4 should be made for procedure to be followed in disposition.

b. Small-arms ammunition should be destroyed in a pit which is approximately 6 feet square and 4 feet deep. An inclined chute such as a piece of 2-inch pipe should be provided, and this chute should be placed so that one end is over the center of the pit and the other behind the barricade. Precautions should be taken to baffle the open end behind the barricade so that the operator cannot look down the pipe. A hot fire should be built in the pit, and then the pit should be covered with a piece of sheet iron or other suitable material to confine flying fragments. The cartridges should be fed into the fire through the pipe, and care should be taken to prevent an accumulation of unexploded ammunition in the pit. A furnace or burning kettle designed to accomplish the above destruction by burning is also satisfactory. Approved equipment and building drawings showing barricades will be supplied by the Chief of Ordnance on request.

236. SMALL COMPONENTS EXCEPT PRIMERS.

a. These components, artillery and grenade fuzes, boosters, detonators, and similar material, may be destroyed either by burning or by detonating. For destruction of primers see paragraph 237.

b. In destruction by burning, the same instructions given in paragraph 235 b for the destruction of small-arms ammunition should be followed. Caution should be exercised in introducing components into the fire because normal action cannot be expected under intense heat. The explosion of a previously introduced component should be heard before introducing another.

c. When destroying these components by detonation, a small number of components, depending upon the type and kind, should be placed in contact with one another in an open container. This container should then be placed in a pit or trench approximately 4 feet deep. On top of each container and in contact with the components, one or more TNT blocks fitted with an electric blasting cap or with a C of E special blasting cap and time fuse (safety fuse) should be placed. The pit should then be covered with a layer of logs and earth or other suitable cover, and the components should then be detonated in accordance with the safety precautions outlined in paragraphs 224 and 226.

d. The following method of destruction of unserviceable HE antitank mine fuzes should be followed:

(1) The available safety distances will determine the number of fuzes that may be destroyed at one time (based on actual fragment distances reported from destruction of fuzes in quantities) together with recommended minimum safety distances for each, as set forth below:

(*a*) Where pile is covered with earth (2 feet):

No. of Fuzes	Fragment Distance (approximate yards)	Recommended Safety Distance (minimum yards)
12	200	400
56	350	525
152	525	800
702	525	800

(*b*) Where pile is not covered with earth:

No. of Fuzes	Fragment Distance (approximate yards)	Recommended Safety Distance (minimum yards)
702*	800	1200

*Other quantities may be selected for detonation at one time, although 702 was adopted as reaching the upper limit of efficiency in piling.

(2) Between storage point and destruction area, handle all fuzes with striker end up; exercise extreme care and caution.

(3) Make a double pyramid pile of the quantity selected for destruction; the bottom row should be on level ground or on a wooden board of sufficient length to carry the bottom row of the pile. Place the fuzes on the side with the rows base to base, in intimate contact, and with the projecting portions of the safety fork fitted into the grooves carrying the same component in the adjacent fuzes. The fuzes must be kept in contact with each other.

(4) Place two No. 6 or No. 8 blasting caps (lightly taped if necessary to hold them in position) side by side between the bases of the two top fuzes of each pyramid so that the end of the cap is at the approximate center of the base of the fuze. A slight "mudcapping" of the caps is desirable if carefully applied. The pile is then ready for detonation.

237. PRIMERS.

a. Large primers, 100-grain or more, may be destroyed by burning according to the instructions for destruction of small-arms ammunition in paragraph 235 b. Primers, other than small-arms primers, are dropped one at a time into the fire. Large primers will be destroyed only in this manner because they are subject to explosion in mass if destroyed by burning in large quantities.

b. Primers, except the 100-grain or larger primers, may be burned in a trench approximately 2 feet deep, 1 foot wide, and of sufficient length to accommodate the number of primers to be burned at one time. The trench should be prepared with a quantity of excelsior or similar combustible material sufficient to insure a hot fire throughout its length. The primers should be removed from boxes and placed on the excelsior before the fire is lighted. Pasteboard cartons need not be opened before they are placed in the trench. To confine fragments as much as possible, a piece of sheet metal should be placed over the trench. After the primers and cover are in place, a train of combustible material leading into the pit should be prepared and lighted. Personnel should then take cover or withdraw to a safe distance.

c. If a suitable tank or kettle is available for use, a smaller number of primers may be placed in it and a small-mesh screen placed over the top. By building a fire underneath, the primers will be exploded. A convenient receptacle is an iron tank cut in half longitudinally and the open side placed on railroad iron or other suitable grating that will not let the primers drop into the fire. A large hole, approximately 12 inches in diameter, with a pipe located above the height of a man's head, should be provided and about 50 primers put in at one time. The boiler should be equipped with a smokestack so that a draft will be formed through the grating. Packing material, if inflammable, need not be removed from the primers.

d. If a burning pit constructed of railroad iron or similar material is available, a fire may be built in it and a box of primers destroyed at one time (provided the packing is inflammable) by throwing the box into the pit and taking cover.

e. The smaller end vent primers may be destroyed by building a firebox, over which a basket of primers may be pulled on railroad iron from behind a barricade. The fire should be started before the primers are pulled over it. When all primers have been fired, the basket should be pulled off, emptied, *cooled*, reloaded, and again pulled over the fire.

f. The stock of primers awaiting destruction will not be allowed within 300 feet of the burning operations, and great care will be taken to protect the pile from accidental ignition by flying fragments or sparks. This stock will be limited to a day's supply. Other applicable regulations contained in paragraph 226 will be strictly observed.

238. GRENADES.

a. **General.** Grenades may be destroyed by burning or detonation in accordance with the following instructions. Strict compliance with applicable regulations of paragraph 226 is essential for the protection of personnel and property. Destruction by detonation should generally be applied to high-explosive grenades, whereas destruction by burning is applied generally to other types of grenades.

b. **Destruction by detonation.** Not more than twenty grenades should be placed in a pit about 4 feet deep. They should be piled so that they come in close contact with each other; on top of the pile should be placed, in intimate contact, three ½-pound TNT blocks, one of which is provided with an electric blasting cap or C of E special blasting cap fitted with several feet of time fuse (safety fuse). The grenades and TNT blocks should be covered with a layer of earth about 1 foot thick which is tamped lightly to obtain the maximum efficiency of the TNT blocks, and the pit should be covered as prescribed in paragraph 226.

c. **Destruction by burning.** A pit 2 feet square by 3 feet deep fitted loosely with an iron plate or heavy board cover is used. Grenades should be put in the fire one at a time. Another should

not be put in until the previous grenade is detonated. Care should be taken in introducing explosives into the fire, as normal action cannot be expected under intense heat. The only time to investigate an unusual delay in the explosion of a grenade is when the fire has burned out and the pit is cold. Instead of dropping grenades singly and covering each time, an inclined chute which is baffled at the open end may be used.

239. PYROTECHNICS.

a. **General.** Pyrotechnics, except photoflash bombs and parachute flares, will be destroyed in accordance with the instructions for burning of primers (par. 237 b). Loose pyrotechnic materials should be burned under the same conditions as black powder and the same precautions should be observed (par. 227 a). Water-wet pyrotechnic materials may be burned in small quantities in furnaces designed for that purpose and approved by the Chief of Ordnance.

b. **Parachute flares.** Parachute flares will be destroyed by burning in the open and in a vertical position on the ground. The individual flares must be located at least 4 feet apart and placed on top of a layer of combustible material. After lighting the train of combustible material, personnel should take cover and observe safety distances.

c. **Photoflash bombs.** Photoflash bombs are dangerous and should be handled with care. They should be destroyed by the use of TNT blocks, similar to the procedure for artillery shell (par. 229). Duds of photoflash bombs should not be handled or moved but destroyed in place in accordance with instructions in paragraph 242. Due to the thinness of the case, a single block of TNT is sufficient to accomplish destruction. A strict compliance with the applicable regulations of paragraph 226 is essential.

NOTE. *Due to the brilliance of the flash, it is injurious to vision to watch the destruction of photoflash bombs even at distances prescribed in this manual as safe against fragments.*

240. CHEMICAL AMMUNITION.

a. In general, grenades, bombs, and shell loaded with chemical filler should be destroyed in a manner similar to that prescribed in paragraph 229 for destroying artillery shell. Before destroying chemical ammunition, however, special instructions should be obtained from the Chief of Ordnance concerning any exceptional hazards. When a leaking shell or component is located, the individual in charge of the magazine will be notified in order that he may direct the disposition of the shell. As chemical shell contains a comparatively small amount of explosives, the charge of TNT blocks to be used for demolition should be as follows:

Chemical Shell or Component	No. of ½-pound TNT Blocks or Their Equivalent
75-mm shell	4
155-mm shell	5
8-inch shell	6
60-mm and 81-mm mortar	2
4.2-inch chemical mortar shell	3
8-inch chemical mortar shell	3
5-lb bomb	1
25-, 30-, and 50-lb bomb	2
100-lb bomb	3

b. Dangerous chemical ammunition.

(1) Immediately hazardous unserviceable chemical ammunition may be destroyed by exploding in the open if a sufficiently isolated area is available. The point where the shell is exploded should be chosen so that for a period of approximately 48 hours personnel can be excluded from the area 1 mile downwind from the point where the shell is exploded. For a period of about 2 weeks, all personnel must be prevented from passing within a distance of 150 yards from the point where the shell is exploded. Where a sufficiently isolated area is not available, single unserviceable gas-filled shell may be destroyed in a pit 6 feet deep. The shell with its bursting charge is placed at the bottom of the pit, the pit is back-filled, and the shell exploded. Five gallons of freshly prepared bleaching solution should be poured on the fill, and sufficient dry bleach (chloride of lime) should then be scattered over the fill to cover the disturbed ground to a depth of 2 inches. A permanent sign should be placed on the fill, prohibiting digging in the vicinity.

(2) Where a sufficiently isolated area is not available, chemical ammunition may be destroyed by placing in a pit, approximately 20 feet in diameter and 4 feet deep, on top of a wooden platform and surrounded by dry scrap wood. Arrange demolition charges and cover the ammunition with about 2 feet of earth; the charges are to be so arranged that they will function after the scrap wood has been ignited and the fire has gained headway; in this way the chemical filler will be burned as it comes from the item without undue contamination of the surrounding area. Under normal conditions, the chemical filler will burn clean and no shell fragments will leave the pit. As a matter of general safety, no personnel should approach the pit for 48 hours.

241. ANTITANK MINES. If marks on the mine or on the ground indicate that it has been run over by a vehicle, the mine should be considered as a dud and should not be handled or jarred, and should be destroyed in place by detonation with a TNT or nitrostarch block (par. 242). Only mines that have not been tampered with, handled, or disturbed in any manner may have the safety fork replaced and then taken up. The safety fork must be replaced

before the mine is handled or the fuze removed. Unserviceable antitank mines will be destroyed in the same manner and with the same precautions as bombs (pars. 229 and 231).

242. TARGET RANGES.

a. General. Explosive missiles which have failed to function after firing are termed "duds." AR 750-10 prescribes that, after firing on a range has been completed and before free access to it is allowed to personnel in general, the range will be thoroughly policed and all duds destroyed by competent personnel. Duds of photoflash bombs or aircraft flares released during flight over land areas other than target ranges will be recovered and destroyed. See paragraph 239.

b. Safety precautions. Target ranges are dangerous because of flying missiles during target practice and unexploded ammunition which may remain on the range after target practice. Safety precautions should therefore include means for preventing trespass upon the target range by unauthorized or careless persons and for removing from the range all unexploded ammunition which has been fired. In addition to the safety measures employed at and near the firing line, such as red flags, markers, or fences, the boundary or terrain which is likely to receive missiles from the firing line should be placarded with signs which indicate the danger zone and the hazards attendant upon entering such zones at specified times. The signs should also emphasize the dangers connected with picking up unexploded ammunition and should prohibit either trespass on the range or the removal of souvenirs from areas, under penalties provided by law. The placarding of the target ranges is a matter of public safety and must never be neglected.

c. Destroying duds.

(1) The policing of a target range and safeguarding the command are functions of the commanding officer. Immediately after target practice is completed, the entire range should be carefully policed for unexploded ammunition, under the supervision of an authorized individual who is thoroughly familiar with the dangers incident to such operations. Unexploded projectiles and other components of ammunition which have been fired are dangerous to handle and should not be touched or jarred where it is practicable to destroy them by the use of TNT blocks. However, unfuzed duds may be handled with comparative safety.

(2) In those rare cases in which it is necessary to remove a dud from any location before destroying it, all operations connected with this procedure should be done either by or under the direct supervision of personnel who are thoroughly familiar with the dangers of such an operation and who are qualified to do this work.

(3) To move or roll an unexploded fired projectile is to invite disaster, as such an operation may cause movement of the internal

fuze parts and may cause the projectile to explode. No attempt will be made to disassemble a round of unexploded ammunition except by personnel of the Ordnance Department who are specifically assigned to such work.

(4) Duds on the target range, such as unexploded projectiles, fuzes, grenades, etc., can usually be destroyed in place with TNT or nitrostarch blocks. The dud should be approached only by experienced personnel and, without disturbing the dud, the explosive blocks carefully laid in intimate contact with it. If possible, the blocks should be placed on top of the dud because the wave of detonation tends to be propagated downward. The blocks should then be carefully mud-packed or earth-covered to direct the explosion toward the dud as much as possible. For artillery shell, the number of TNT blocks (or equivalent) to be used should follow the table specified in paragraph 229 c. After placing the charge, the dud should then be covered with sandbags or earth to limit the range of the fragments.

(5) Shell exploded on the ground surface without an earth cover of at least 2 feet, may send fragments 1,000 yards, and all within this danger zone will take cover when the charge is fired. Personnel should never be within 300 feet of a projectile when it explodes, even if suitable protection is at hand. The general instructions for destroying duds on the target range are similar so far as possible to those described for destroying artillery ammunition (par. 229). Duds of photoflash bombs are destroyed in accordance with this paragraph and paragraph 239. The safety precautions in paragraph 226 will be carefully observed.

(6) Gas shells or bombs should be handled in the same manner as other projectiles. Holes or trenches in which gas shells have been exploded must be filled or decontaminated and gas masks worn during the work. Work should always be done on the windward side of the area where gas shells are exploded.

(7) Destruction of duds of spotting-charge assemblies, for the 100-pound practice bomb M38A2 (black powder) will be accomplished by detonation in place. This can be done by the use of demolition blocks or a 15-inch length of primacord which is coiled, placed on top of the charge, taped in place, and detonated with a blasting cap. Destruction of individual unserviceable spotting charges of this type can readily be accomplished by winding a 20-inch length of primacord twice around the charge, taping it in position, and initiating detonation by means of a blasting cap as above.

(8) After the destruction of duds has been completed, the officer in charge of the work will personally superintend a thorough search of the area to insure that no duds have been overlooked.

(9) Additional information on destruction of unexploded projectiles and bombs may be found in FM 9-40 and FM 5-25.

CHAPTER 5

REFERENCES

243. PUBLICATIONS INDEXES. The following publications indexes should be consulted frequently for latest changes or revisions of references given in this chapter and for new publications relating to materiel covered in this manual:

a. Introduction to Ordnance Catalog (explaining SNL system) .... ASF Cat. ORD 1

b. Ordnance Supply Catalog Index .... ASF Cat. ORD 2

c. Ordnance Major Items and Combinations, and Pertinent Publications .... WDSB 9-1

d. List and Index of War Department Publications FM 21-6

e. List of War Department Films, Film Strips, and Recognition Film Slides .... FM 21-7

f. Military Training Aids .... FM 21-8

g. Index to Bombing Tables (listing current bombing tables for bombs, clusters, and flares) .... Index to BT's

244. STANDARD NOMENCLATURE LISTS.*

a. Ammunition for small arms.

Ammunition, revolver, automatic pistol, and submachine guns .... ASF Cat. ORD 11 SNL T-2

Ammunition, rifle, carbine, and automatic gun ASF Cat. ORD 11 SNL T-1

Ammunition, small-arms, obsolete and nonstandard .... ASF Cat. ORD 11 SNL T-6

Miscellaneous service components of small-arms ammunition and instruction material for Field Service Account .... ASF Cat. ORD 11 SNL T-4

Packing materials used by Field Service for small-arms service ammunition ASF Cat. ORD 11 SNL T-5

Shells, shotgun .... ASF Cat. ORD 11 SNL T-3

b. Bombs, grenades, pyrotechnics, and rockets.

Ammunition instruction material for grenades, pyrotechnics, and aircraft bombs ASF Cat. ORD 11 SNL S-6

Bombs, aircraft, all types .... ASF Cat. ORD 11 SNL S-1

*An up-to-date listing of current Standard Nomenclature Lists is maintained in ASF Cat. ORD 2.

References

Fuzes and miscellaneous explosive components for aircraft bombs .... ASF Cat. ORD 11 SNL S-2

Fin assemblies and miscellaneous inert components for aircraft bombs .... ASF Cat. ORD 11 SNL S-3

Grenades, hand and rifle, and fuzing components ASF Cat. ORD 11 SNL S-4

Pyrotechnics, military, all types ASF Cat. ORD 11 SNL S-5

Rockets, all types, and components ASF Cat. ORD 11 SNL S-9

Torpedoes and mines .... ASF Cat. ORD 11 SNL S-1

c. Cleaning, preserving, and lubricating materials; recoil fluids, special oils, and miscellaneous related items .... ASF Cat. ORD 5 SNL K-1

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Chemical Warfare Service Supply Catalog. List of Items for Troop Issue .... ASF Cat. CW 3

Engineer Supply Catalog. Stock List of All Items .... ASF Cat. ENG 5

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Administration; posts, camps, and stations	AR 210-10
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Regulations for transportation of explosives and other dangerous articles by land and water in rail freight, express, and baggage services, and by motor vehicle (highway) and water	Interstate Commerce Commission
Methods for loading and staying carload and less than carload shipments of explosives and other dangerous articles (Pamphlet No. 6)	Bureau of Explosives, 30 Vesey Street, New York City

Methods for loading and bracing carload and less than carload shipments of loaded projectiles, loaded bombs, etc. (Pamphlet No. 6A)	Bureau of Explosives, 30 Vesey Street, New York City
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I.C.C. Freight Tariff No. 4	Interstate Commerce Commission
Interstate Commerce Commission regulations for transportation of explosives and other dangerous articles by freight	Bureau of Explosives, 30 Vesey Street, New York City
Regulations governing transportation of military explosives on board vessels during present emergency	U. S. Coast Guard
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Standard specification for marking shipments by contractors	U.S. Army Specification No. 100-2E
Transportation in the Zone of the Interior	TM 55-205

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Crosby-Fiske-Forster Handbook of Fire Protection	National Fire Protection Association
Fire-fighting	John J. McCarthy, Asst., Chief of Dept. in Command, N. Y. Fire Dept.
Fire Protection by Troop Organizations in Theaters of Operations	FM 5-315
Industrial Fire Brigades, 1st Edition	National Fire Protection Association
Suggestions for Fire Fighting and Fire Extinguishment	Navy Dept. Bureau of Yards and Docks

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WAR DEPARTMENT TECHNICAL MANUAL
TM 9-1904

Ammunition Inspection Guide

WAR DEPARTMENT • *2 MARCH 1944*

RESTRICTED *DISSEMINATION OF RESTRICTED MATTER—* **The information contained in restricted documents and the essential characteristics of restricted material may be given to any person known to be in the service of the United States and to persons of undoubted loyalty and discretion who are cooperating in Government work, but will not be communicated to the public or to the press except by authorized military public relations agencies. (See also paragraph 18 b, AR 380-5, 28 September 1942.)**

WAR DEPARTMENT
Washington 25, D. C., 2 March 1944

TM 9-1904, Ammunition Inspection Guide, is published for the information and guidance of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

DISTRIBUTION: IBn 9 (2); IC 9 (2), (10).

(For explanation of symbols, see FM 21-6.)

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AMMUNITION INSPECTION GUIDE

SECTION I.
INTRODUCTION

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GENERAL.

When venturing into any new field, one finds himself confronted with many new terms and materials to such an extent that he often becomes lost in a maze of confusion. It is, therefore, necessary to lay a foundation of information that will aid in interpreting the material which will follow.*

It is necessary for the ammunition inspector to have a wide and complete knowledge of all the types of ammunition that he will come in contact with in the line of duty, for he will be called on to pass judgment as to the safe conduct of various operations. To do this, he must know all the facts about the material in question. It might be well to point out that all ammunition is inherently dangerous, for its whole purpose of existence is to destroy or kill, but, if handled correctly and carefully, one need not be afraid to work with it. At all times, however, it must be given the fullest respect. A great portion of the accidents which do occur can be traced to some form of carelessness when the full measure of safety was not applied.

Nomenclature. In his daily duties, the ammunition inspector will be called upon to discuss ammunition. Whether this discussion be written or oral, the proper use of terms or proper nomenclature is constantly required. All articles have specific names and designations which must be used at all times. The purpose of this is to insure that there will be no error in understanding, for some types of ammunition are so nearly alike that only by the use of proper terminology can they be distinguished. The habit of using proper nomenclature is one that should be formed from the beginning.

Model Designations. To distinguish a particular design, a model designation is assigned at the time the model is classified as an adopted type. This model designation becomes an essential part of the standard nomenclature and is included in the marking on the item.

Prior to World War I, the number of the year in which the design was adopted preceded by an "M" was used as the model designation; for example, M1906. From the World War until July 1, 1925, it was the practice to assign mark numbers. The word "Mark," abbreviated "Mk.," was followed by a roman numeral; for example, Shell, H.E., Mk. III. The first modification of a model was indicated by the addition of MI to the mark number, the second by MII, etc. The present

* This Technical Manual has been published in advance of *complete* technical review in order to provide a background for inspection of all types of ammunition.

system of model designation consists of the letter "M" followed by an arabic numeral. Modifications are indicated by adding the letter "A" and appropriate arabic numerals. Thus, M2A1 indicates the first modification of an item for which the original model designation was M2. In addition to the "A" modifications there are also "B" modifications. These may be either a change in the method of manufacture of an item, or a change in the material used. Examples of this are the M18B1 steel cartridge case and the M1B1A1 primer. Certain items standardized for use by both Army and Navy are designated by the letters "AN" preceding the model designation; for example, AN-M100A1, AN-Mk. 19, AN-Mk. IV. The two designations above, AN-M100A1 and AN-Mk. IV, indicate that the item is of Army design, while the designation AN-Mk. 19, indicates that the item is of Navy design. In recent years the Navy designations have been arabic numerals, previously they were roman numerals and some of these may still be found.

Classification by Standards.

Standard articles are those which are the most advanced and satisfactory, and have been adopted by the Secretary of War. They are preferred for procurement to meet supply demands.

Substitute standard articles are those which do not have completely satisfactory military characteristics, but are usable substitutes for standard articles. They are not normally in use, nor are they available for issue to meet supply demands. They may, however, be procured to supplement the supply of standard articles.

Limited standard articles are those which do not have as satisfactory military characteristics as standard articles, but are usable substitutes for standard articles. They are either in use or available for issue to meet supply demands.

Classification by Issue and Manufacture. In making use of the Standard Nomenclature Lists and Complete Round Charts, the status of the ammunition may be found marked as "S" or "S&M." In this instance, the "S" indicates that the item is standard for issue only and is no longer being manufactured. The "S&M" indicates that the item is standard for issue and is being manufactured.

Ammunition Lot Number. When ammunition is manufactured, a lot number, which becomes an essential part of the marking, is assigned in accordance with pertinent specifications. This lot number is stamped or marked on every item of ammunition unless the item is too small. A group of these lots which for both engineering and statistical reasons can be considered to be of the same standard of quality is called a grand lot. In addition to this lot number, there is assigned to each complete round of fixed and semifixed ammunition an *ammunition lot number* which serves to identify the conditions

under which the round was assembled and the components used in the assembly. This ammunition lot number is marked on every complete round of fixed and semifixed ammunition (except where the item is too small as in the case of small-arms ammunition) and on all packing containers. It is required for all purposes of record including reports on condition, functioning, and accidents in which the ammunition is involved. To provide for the most uniform functioning, all of the components in any one lot are manufactured under as nearly identical conditions as practicable. For example, in the case of fixed ammunition, all of the rounds in any one lot consist of:

1. Projectiles of one lot or grand lot (one type and one weight zone).

2. Fuzes of one lot or grand lot.

3. Primers of one lot or grand lot.

4. Propellent powder of one lot.

DEFINITIONS.

A few basic definitions are essential if one is to attain complete understanding of the material which is to follow.

Ammunition. Ammunition is defined as any or all materials used to charge weapons of war, including pyrotechnics in all of its forms.

There is one point in this definition that might not be clear. "Weapons of War" refers to not only guns, howitzers, mortars, and the like, but to airplanes and soldiers as well.

Caliber. Caliber is a term which has widespread use in the field of an ammunition inspector. Nearly all of the ammunition is measured in calibers. A caliber is the diameter of the bore of the weapon between opposite lands. While it is used as a unit of measure and is expressed in inches or millimeters, it has no unit in itself. Thus, if it is said that the barrel of a particular weapon is 30 calibers in length it does not mean that it is 30 inches or 30 millimeters long, but that its length is 30 times the diameter of its bore between opposite lands. To be of any use, caliber must refer to a specific weapon.

Lands. The lands in a weapon are the raised portions of the rifling of the weapon, and the spaces between the lands are called *grooves.*

Complete Round. A complete round of ammunition is made up of all the necessary components to a chain of events which will perform a desired function under the proper circumstances and at the proper time. For example, a complete round of a high-explosive shell would be made up of a projectile, an explosive filler, a fuze, a booster, a propelling charge, a cartridge case, and a primer. Here, all of these components are necessary to bring about the desired function of the shell and thus make up a complete round.

Small-arms and Artillery Ammunition. A most important dividing line in ammunition is that between small-arms and artillery ammunition. This dividing line is based on 0.60 inch. Small-arms ammunition is defined as ammunition fired in weapons whose bores are 0.60 inch or less in diameter, while artillery ammunition is defined as ammunition fired in weapons whose bore is over 0.60 inch in diameter. It is well to note that small-arms ammunition includes ammunition which is 0.60 inch in diameter, and that anything over 0.60 inch must be considered as artillery ammunition.

ARTILLERY AMMUNITION.

Tactics and Ammunition. Artillery was first used mainly against fortifications for the purpose of breaking down walls to allow the passage of foot troops in an attack. Because the hand weapons of the defending forces were crude and of short range, the cannon of the attacking force could be emplaced at close range. There was, therefore, no need for long-range fire, and artillery was put into position in front of the foot troops. With the development of shoulder weapons of increased range and accuracy, it became necessary for artillery to seek positions at greater distances from the opposing forces and in the rear of friendly troops who served to protect the artillery division.

These conditions called for greater range and power, which in turn necessitated improved projectiles and propellent powders. The assignment of special missions to artillery brought about the development of special ammunition with which to accomplish these missions.

Projectiles. A projectile is a missile, either solid or with an explosive, chemical, or inert filler, propelled from a weapon by the force of gases produced by a propelling charge.

Early projectiles fired from cannon were iron darts, wrapped with leather, of a size to fit the bore. These continued in use up to the sixteenth century, when they were replaced by spherical shot. One example of this shot was roughly rounded stone balls chosen because of their cheapness. Forged iron, bronze, and lead balls were tried, but expense prevented their general adoption.

Also, since heavy metal shot necessitated the use of a correspondingly large propelling charge, too great a strain was exerted on the feeble artillery pieces of the period. This frequently caused rupture of the cannon. Stone shot being about one-third the weight of iron, the powder charge was reduced in proportion, effecting an additional economy.

Both iron and stone shot occasionally were covered with lead to preserve the interior of the bore by reducing the friction, and to afford a closer fit between the shot and the bore, thereby improving the obturation, preventing the escape of gases, and increasing the muzzle velocity and range. Hollow projectiles filled with explosives or combustibles, and variations of canister appeared during the sixteenth century.

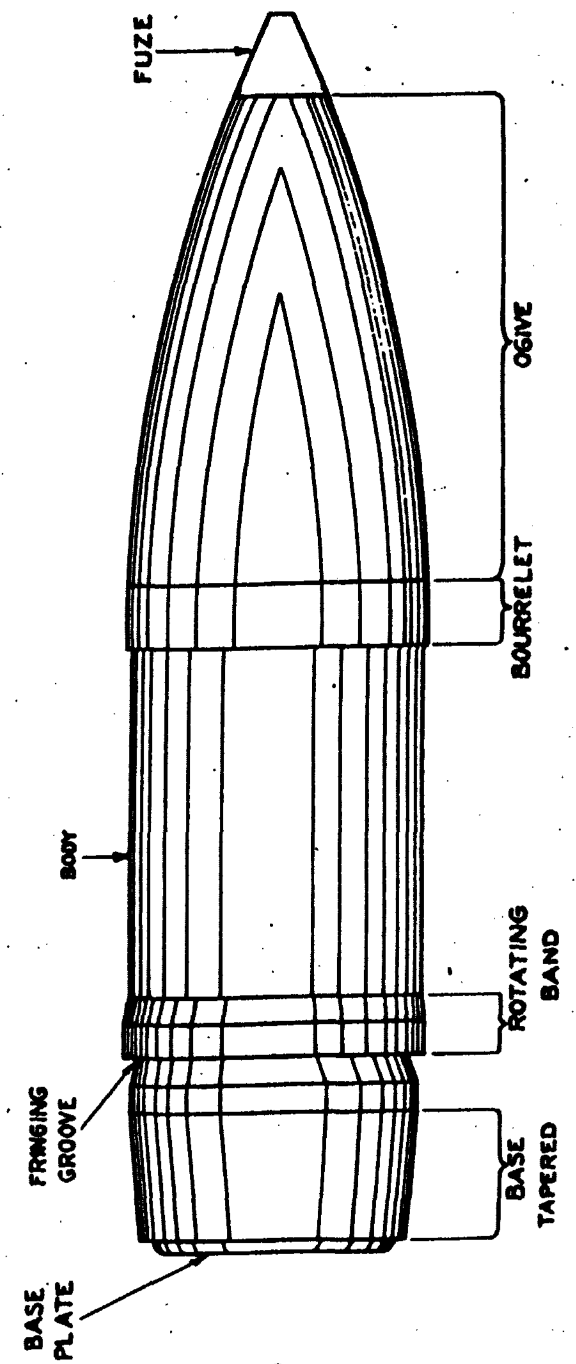


Figure 1 — Projectile

Shape. Since its inception, the demand for greater and greater range has influenced the shape of the projectile. Toward the end of the sixteenth century, cannon shot was made of cast iron and was spherical in form. The spherical projectile was inefficient ballistically, it was erratic in flight. Because of the crude methods of manufacture, a tight fit could not be obtained between the projectile and the bore of the cannon. Its rough surface increased air resistance and, by virtue of its shape, a maximum surface in proportion to its weight was effected by resistance. Nevertheless, the spherical form continued in use up to the advent of rifled cannon (about 1860), when projectiles were elongated to a cylindrical form with a pointed nose.

Factors affecting desired shape. The amount of air resistance depends upon the size, shape, and "presentation" of the projectile. Size is significant because of the greater number of air molecules to be displaced by movement of the larger projectile. Shape of the projectile has an important effect on the manner in which the molecules are shouldered aside. "Presentation" affects both the number of air molecules displaced and the manner in which they are pushed aside. A projectile of 2 feet in diameter displaces four times as many molecules as does a projectile of 1-foot diameter, since the area of the cross section of a projectile varies as the square of the diameter. A cone with a base diameter of 2 feet, since its greatest cross section is the same as a cylinder of the same diameter, displaces just as many molecules as does the cylinder, but because of its pointed shape, it effects the displacement more smoothly and consequently encounters less resistance.

Weight exercises a great effect on the power to overcome resistance. Thus, two cylinders of equal diameter and length composed of different materials, one twice as heavy as the other, would experience the same resistance to travel through the air. However, the heavier would possess double the ability of the lighter to overcome resistance.

Again, since length has little effect on resistance, a cylinder twice the length of the original one and composed of the same material, if solid, would be twice as heavy and would possess double the energy. In order that a cone may possess the same energy as a cylinder of equal diameter, it must be longer, since it otherwise would be of less weight. As the length of a projectile is limited by certain other considerations, the modern projectile represents a compromise, combining energy-producing effect by means of increased weight, and resistance-reducing effect by means of the pointed nose.

The air resistance is affected in a marked degree by the shape of the nose. It is found that in a shell in the usual form, the shape of the shoulders is more important than that of the actual point. This is explained by the fact that as air streams outward from the point to pass over the shoulders of the shell, it leaves a partial vacuum

near the point while the main air pressure comes near the shoulders. When a projectile with a radius of ogive of 5 or 6 calibers is used, the shape of the point becomes important in determining the direction of the air currents which flow over the shoulders.

The ideal shape for a projectile intended to travel through the air with the minimum resistance would be one of streamline profile and having a nose with an ogive curved for pushing aside the air molecules with the least disturbance. It would also have a tapered or conical ("boat-tailed") tail to eliminate vacuum-forming eddies in its wake. The flat, sawed-off bottom of the type of projectile in use prior to World War I is inefficient, because the partial vacuum formed behind the projectile during flight greatly retards it and causes unsteadiness in flight. For this reason modern projectiles are of the "boat-tailed" type.

Exterior of Modern Projectiles. Modern projectiles combine weight and form in the most practical way to secure a maximum of stability and a minimum of air resistance in flight.

Ogive. Starting with the point of the projectile and working toward the rear, the first portion encountered is the curved portion of the nose of the projectile. This is known as the ogive. The ogive describes an arc whose center lies on a plane perpendicular to the axis of the projectile, with a radius usually expressed in terms of caliber. This radius formerly was two calibers for all projectiles, but experiments have proved that a marked reduction in air resistance, resulting in greater range, can be obtained by increasing the radius of the ogive to as much as 10 or 11 calibers.

Bourrelet. Directly behind the ogive is a very carefully and accurately machined portion of the projectile, known as the bourrelet. It is this portion of the propectile which most nearly conforms to the bore of the weapon. In action, it acts as a forward bearing surface, and also helps to center the projectile in the bore of the weapon. The average bourrelet is about 1/6 of a caliber in width. By having only a small band such as the bourrelet for a bearing surface, the amount of resistance due to friction in the bore is greatly reduced as compared to the friction which would be produced if the whole body of the projectile were to contact the lands.

Body. The cylindrical portion of the projectile directly behind the bourrelet and extending to the rotating band is commonly called the body. This is slightly smaller in diameter than the bourrelet and is usually 1 to 2 calibers in length.

Rotating band. The purpose of the rotating band is to cause rotation of the projectile about its axis, in order to give it stability in flight. If the projectile did not rotate in flight, it would fly end over end or tumble; its flight would be irregular and inaccurate, and the range would be reduced. The rotating band, by engaging the lands

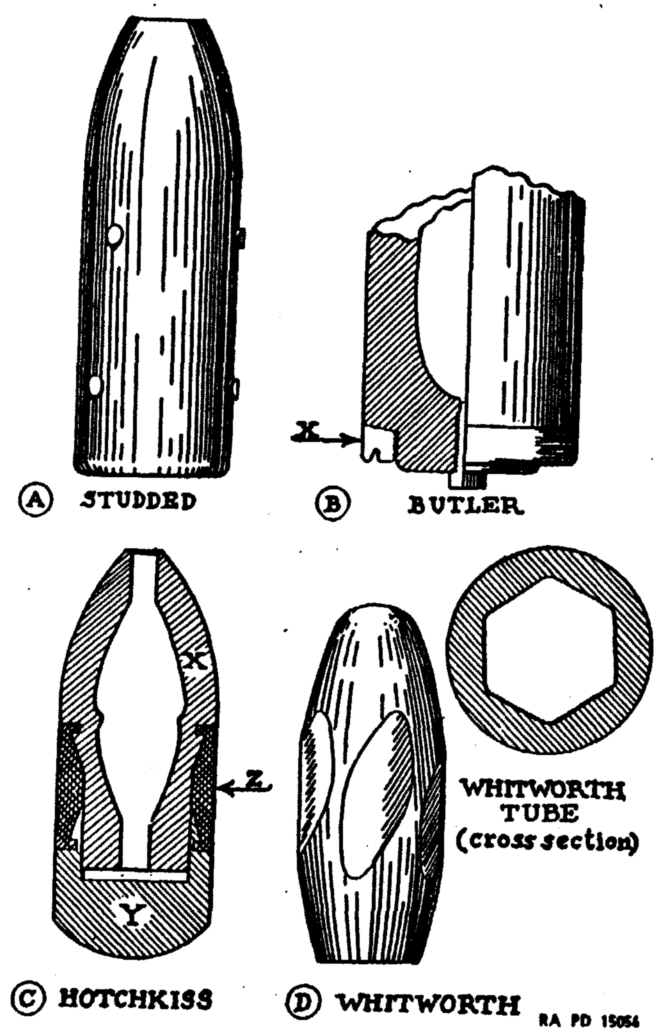


Figure 2 — Means of Obtaining Rotation, Early Projectiles

and grooves in the bore of the weapon, gives the projectile this rotation.

Before the advent of the rotating band, many devices were tried in order to obtain rotation. One means was to provide the projectile with a series of studs which were fitted into the grooves of the rifling as the projectile was inserted at the muzzle. This type of projectile was known as the "studded" type.

A second type of projectile was the "Butler" type. This projectile was fitted with a ring of brass at the rear of the projectile which

would expand when acted upon by the pressure of the gases from the propelling charge. This expansion caused the brass to fit into the grooves of the rifling and thus gave rotation to the projectile.

Another early type of projectile was the "Hotchkiss" type. This projectile was manufactured in three parts; the forward portion of steel, a rear portion also of steel, and the two held apart by a lead ring. When the round was fired, the rear portion forced against the lead ring which expanded into the grooves and thus gave rotation to the projectile.

A different method entirely was found in the "Whitworth" gun and projectile. In this model, the weapon was fitted with a hexagonal bore, twisted in the same manner as the rifling in the other types. The projectile was fashioned to fit the bore, its sides being provided with flattened surfaces of a similar pattern.

With the introduction of breech-loading cannon, the problem of giving rotation to the projectile was simplified. As previously explained, the raised portions between the grooves are known as the lands. The bourrelet of the projectile has the approximate diameter of the lands. At the rear of the projectile is a smooth band of soft metal which has the diameter of the grooves. The projectile is inserted into the smooth-surfaced chamber in the rear of the rifled portion of the bore, and then is rammed forward. The grooves engage the soft metal of the rotating band and hold the projectile in place while the tube is elevated. On the explosion of the propelling charge, the projectile moves forward and the lands cut into the rotating band, causing it to conform to the rifling. This gives the projectile a rotary motion about its long axis.

Since the band of a modern projectile completely fills the grooves, it prevents the escape of gas past the projectiles and centers the projectile in the bore. The front surface of the band is machined to seat itself readily in the coned seat at the origin of rifling. This coned seat is known as the forcing cone.

The metal of the rotating band must be soft enough to flow readily to fill the rifling grooves, and to prevent excessive wear of the lands. It must be hard enough to prevent stripping under the resistance met in rotating the projectile and to avoid fouling the bore. Both copper and gilding metal seem to be favored as the best metals for rotating bands.

Certain projectiles for the 155-mm gun have two rotating bands, but generally there is only one rotating band on each projectile for all guns and howitzers.

Fringing groove. During firing, a small amount of the copper of the rotating band is forced back behind the band and along the surface of the projectile in the rear of the band. The pressure of the released gas at the muzzle of the piece and the centrifugal force of

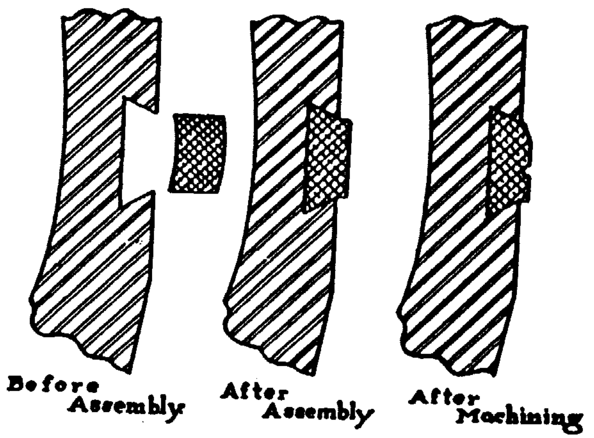
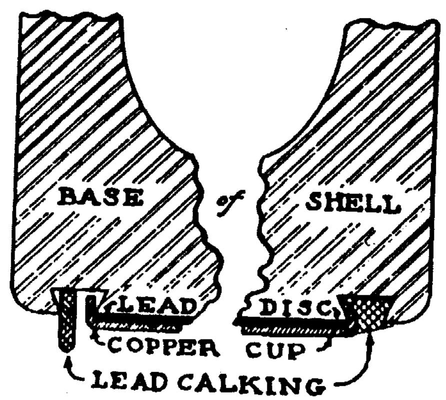


Figure 3 — Assembly of Rotating Band RA PD 15057

rotation combine to throw out this excess metal in a radial direction, so that it becomes a fringe around the rear part of the band. When this fringe is excessive and irregular, it builds up air resistance, lessens the stability in flight, and causes decreased range and decreased accuracy. This fringing is eliminated to a great extent by cutting a fringing groove around and in the rear of the band.

Boat-tail. In order to reduce the vacuum forming eddies at the base of the projectile in flight, the base is tapered to an angle of from 6 to 8 degrees. These vacuum eddies, if present, tend to hold back the projectile and thus reduce the range.

Base plates. Artillery projectiles containing high explosives are fitted with base plates. These are designed to prevent the hot gas of the propelling charge from coming in contact with the explosive



RA PD 15058

Figure 4 — Base Plate Assembly

filler of the shell through possible defects in the base. Three types of base plates are in use.

The older type, common to all calibers, consists of a slightly dished brass plate covering a lead disc, the brass plate being crimped to the base of the projectile.

The new type, for small and medium calibers, has a disc of sheet brass or steel sweated to the base of the projectile with solder, or a steel disc welded to the base of the projectile.

For the larger calibers, the base plate assembly consists of a copper cup covering a lead disc. The copper cup is held in a dovetailed groove in the base of the projectile by means of a strip of lead calking wire, which is hammered down to fill the groove completely and to bend the flange of the copper cup. However, in large caliber projectiles that are not fitted with base fuzes, the steel disc is welded to the base.

Painting. All projectiles are painted primarily for the prevention of rust. The color of the paint, however, is varied for the different types of projectiles and thereby becomes a basic means for identification. The explanation of the color scheme is as follows:

1. Projectiles filled with high explosive, such as amatol, explosive D, TNT, etc., are painted olive drab and stenciled in yellow.

2. Shrapnel and low-explosive shells are painted red. This indicates that they contain a charge of low explosive.

3. Projectiles that are solid or filled with an inert filler are painted black.

4. Ammunition to be used for practice is painted blue. This painting holds even though the projectile may be solid or filled with a black powder (low-explosive) spotting charge.

5. Chemical shell are painted with a blue-gray base color, stenciled with a color which corresponds to its chemical classification, and have circumferential painted bands of the same color.

Projectile Fillers.

Solid shot. The earliest projectiles were spheres of solid metal and depended for their effect upon their weight and velocity, no attempt being made to produce effect by explosion at the target.

Case shot. The first departure from the solid type of projectile came with the advent of case shot. Case shot can be traced back to the early part of the fifteenth century; it retained its original form throughout the entire period of its use. It was intended for use at close quarters when a volley of small shot was required.

Case shot consisted of a cylindrical container of tin with a cast or sheet iron bottom and top plate. The container was filled with small round shot and the voids were packed with sawdust to prevent undue movement of the balls due to the shock of discharge. The shock of discharge disrupted the case, and the balls were scattered shortly after leaving the muzzle of the cannon. Case shot was very effective against troops at short range owing to the wide pattern made by the spreading shot, but when the range exceeded 500 or 600 yards, there was practically no effect.

Grapeshot. A variation of case shot, known as grapeshot, consisted generally of three tiers of cast iron balls separated by iron plates and held in place by an iron bolt which passed through the center of the plates. The effect of grapeshot was similar to that produced by case shot.

Explosive shell. Explosive shell do not appear to have been in general use before the middle of the sixteenth century. About that time, hollow balls of cast iron were fired from mortars. The balls were almost completely filled with gun powder; a small space was filled with a slow-burning composition. The slow-burning composition was ignited by the flash of discharge, and burned until the flame reached the bursting charge. As there was no way of accurately regulating the time of burning, some of the projectiles burst during flight, but many of them did not explode until a considerable time after they had struck the ground. With the development of more accurate fuzes, these projectiles became formidable missiles against fortifications, and were used with some effect against personnel in the open.

Modern shell, made of forged steel, are filled with high explosive, and upon burning a predetermined time, or upon impact, explode with terrific energy, breaking up the shell walls into several hundred fragments. Depending upon the fuze employed, they are designed either to burst in the air or promptly on impact, for effect against personnel, or to penetrate a short distance before explosion for the purpose of destruction.

Armor-piercing. Armor-piercing projectiles consist essentially of a steel shell to which is attached, usually by crimping, a steel armor-piercing cap, and to this cap is attached, by screw threads or crimping, a windshield for ballistic purposes. The projectile may be either filled with explosive D or may be inert. A very important part of the modern armor-piercing projectile is the cap. Against face-hardened armor, projectiles which would be useless without the cap are, with its assistance, able to penetrate in bursting condition. The cap is made of high-carbon chrome steel and heat treated so that the portion directly in front of the point of the projectile is very hard while the skirt is very tough. The period during which the cap performs its functions is so very short and the forces which act on it are so great that it is impossible to say exactly what takes place, but certain theories have been advanced and seem to be borne out by experiment. It is now generally accepted that the principal function of the cap is to place the armor under great stress, flaking the hardened

surface and destroying it, permitting the projectile body to reach the inner layers at an instant when they are already stressed in a favorable direction. The cap also lends lateral support to the point at the instant of impact, preventing a deformation which would result in disintegration of the projectile before perforation could be accomplished.

The cap also performs the valuable function of increasing the angle of obliquity at which penetration or perforation will take place, thus tending to avoid ricochet.

The function of the windshield is to increase the ballistic efficiency of the projectile by enabling it to overcome more readily the retarding effect of the atmosphere with a consequent increase in range. The windshield is made of brittle material and shatters on impact with the target.

The steel shell, or body, finally does the actual penetrating of the armour plate, and if loaded with an explosive filler, will explode after penetrating.

Shrapnel. The shrapnel projectile was developed during the latter part of the eighteenth century as a result of the lack of an effective projectile for use against troops in the open beyond the range of case shot.

The original shrapnel was a spherical shell filled with lead musket balls mixed with the bursting charge. With the advent of rifled guns, the form of the shrapnel projectile has changed, but its character has remained. Modern shrapnel cases are made of forged steel. The lead balls are contained in a matrix of smoke-producing compound and are separated from the base charge by a steel diaphragm. They are provided with a time fuze designed to cause the projectile to burst either during flight or on impact. Shrapnel is designed to carry the balls to a point over the heads of troops and, by the functioning of the fuze and base charge, to scatter the balls with increased velocity over a considerable area.

Chemical shell. Chemical shell are a development of World War I, resulting from the desire to transfer quantities of chemicals into enemy territory. Chemical projectiles are filled with chemical compounds designed to produce casualties, or with smoke-producing compositions for use in screening certain areas from view. Very little effect is produced by fragmentation, since the bursting charge is just sufficient to crack the projectile and scatter the chemical filler. In firing chemical shell, it is important that the shell burst before entering the ground, in order that the chemical be spread instead of being concentrated in and near the shell crater.

Fuzes.

Early fuzes. A fuze is a mechanical device to function the projectile at the time or place desired. Proper functioning of projectiles depends upon accurate and efficient fuzes.

It may be said that fuzes, from the start, have had more influence on the effectiveness of artillery than any other single item. Early explosive shell and shrapnel, more often than not, were wholly ineffective because of uncertain fuzes.

Early fuzes not only were inaccurate and uncertain of action, but also were dangerous to use. Many accidents resulted from prematures caused by defective fuzes. Even with the most modern fuzes in use today, a certain percentage of duds may be expected, and the safety devices are not infallible.

The first fuzes used were short iron or copper tubes filled with slow-burning composition and screwed into the fuze hole of the shell. The slow-burning composition was ignited by the flash of discharge and, when consumed, transmitted the flame to the bursting charge of the shell. There was, at first, no means of regulating the time of burning. Later, about the end of the seventeenth century, the fuze case was made of wood, so that by boring a hole through the outer casing into the composition, the fuze could be made to burn approximately for a given time before exploding the shell; or the fuze could be cut to the correct length for the same purpose.

Early attempts to produce percussion fuzes were unsuccessful, but the discovery of mercury fulminate in 1799 finally afforded the means of attaining this object. Some 50 years elapsed, however, before a satisfactory fuze was made. This was the Pettman fuze, in which a roughened ball covered with a detonating composition was released by the discharge of the piece. When the shell struck any object, the ball was thrown against the interior walls of the fuze, thereby exploding the composition and, consequently, the bursting charge of the shell.

World War I types. Much ingenuity and labor have been expended in the effort to produce safe and accurate fuzes for all purposes. World War I types were satisfactory, in general, for their purpose of detonating or exploding the bursting charge at the time and under the circumstances desired. However, safety devices were not sufficiently refined to insure complete safety against premature action in transportation and loading, and during travel through the bore of the piece.

Another serious disadvantage of World War I types of detonating fuzes was the fact that they could not be set at will for superquick or delay action. This necessitated a supply of all three types in the field.

Later types. Most of the disadvantages enumerated above have been overcome in the recently developed fuzes. These are explained in the chapters dealing with fuzes.

Adapters and Boosters. Since the small detonator contained in the fuze is not powerful enough to insure complete detonation of the shell filler, it is necessary to have a slightly larger quantity of high explosive, more sensitive than the shell filler, to amplify the detonating wave and insure the detonation of the filler. This intermediary filler is the booster. In recent years, boosters have been designed to be assembled directly to the projectile, the old "adapter-boosters" being discarded. The fuze is customarily screwed into the booster. Boosters are used in all high explosive and chemical shell for all guns and howitzers.

The old "adapter-boosters" consisted of an adapter and a booster which were held together as one piece. The adapter was designed to decrease the diameter of the nose of the shell so that the fuze could be screwed into place. The booster was simply a casing of high explosive.

The term "booster," when applied to chemical shell, is converted to "burster," as the function of this component is to break up the shell and disperse the chemical filler. The burster charge is therefore greater than in the high-explosive booster.

Propellants. A propellant is an explosive which, upon burning, propels the projectile from the tube of the gun. It is the final link in the low-explosive train.

Early propellants. The earliest propelling powder was black powder, of about the same composition as we know it today. In the sixteenth century, it was used in the form of a fine powder or dust, but owing to the difficulty of loading this fine dust into the muzzle of small arms, a granular form was developed about the year 1600, and continued in use for more than 200 years.

Smokeless powder. Smokeless powder came into use about 1890, and quickly replaced black powder as the universal propellant for artillery projectiles.

The first Army Ordnance experiments with smokeless powder were with nitrocellulose-nitroglycerine, or "double-base" powder, which type was used in small-arms ammunition until 1906.

The smokeless powder now used consists essentially of a gelatinized nitrocellulose in the form of short multiperforated grains. The United States and other countries have developed powders in the form of long tubes or flat ribbons and cords which usually contain a certain percentage of nitroglycerine.

Because of their hotter gases of combustion, nitroglycerine powders produce more erosion in the bore of the piece than nitrocellulose. For this reason, the latter are generally used as propellants.

A full discussion of smokeless powder will be found in the chapter covering low explosives.

Propellent Containers. According to the method of assembly for transportation and for loading into the piece, ammunition is classified as "fixed," "semifixed," or "separate-loading" (unfixed).

Fixed Ammunition. This type comprises a cartridge case (which contains the propellant) whose base contains the primer, and whose forward opening is crimped to the projectile so that the entire round is integral and all components are loaded into the weapon in one operation.

Semifixed Ammunition. This type differs from fixed ammunition in that, while the projectile and cartridge case are issued assembled and are loaded into the gun as a unit, the cartridge case is not permanently attached to the projectile, but may be removed at the firing point for the purpose of varying the amount of propelling charge as desired.

Separate-loading Ammunition. The distinguishing characteristic of separate-loading ammunition is that it requires two or more operations to be loaded into the breech of the gun. The propellant and primer are loaded separate from the projectile. The propellant is contained in either cartridge bags in definite quantities, or loosely in an uncrimped cartridge case. In the former instance, the amount of propelling charge may be varied as desired. The primer is generally inserted after the breechblock has been closed.

Primers. A primer is used to ignite the propelling charge of smokeless powder. The primer is loaded with a charge of black powder which, in ammunition for small calibers, is sufficient to ignite the propelling charge. In the larger calibers, additional ignition powder is required.

With fixed and semifixed ammunition, the primer is forced into the base of the cartridge case before loading the propelling charge.

With bag-loaded (separate-loading) charges the primer is inserted in the firing mechanism in the breech of the cannon. Primers for separate-loading ammunition are of the obturating type, in that the body of the primer is thin, so that, when the primer charge explodes, the primer will be expanded and pressed tightly against the inner surface of the primer cavity, thus preventing the escape of propelling charge gases to the rear.

Classification. The general classification of primers is based on the method of firing or initiating the ignition, as follows; percussion, friction, electric, combination percussion-electric, and igniting. The detailed description and functioning of these types will be taken up in the chapters covering the complete rounds.

Chapter 2

Safety

GENERAL.

In the line of duty as an ammunition inspector, the full meaning of safety must be kept in mind at all times. This is indicated by the fact that the "Ordnance *Safety* Manual" is the inspector's "Bible." No matter what the operation or procedure may be, the inspector's thought should always be, "Is it safe?"

There are several references where general safety regulations may be found, such as, The Ordnance Safety Manual, Safety Bulletins, TM 9-1900, and other manuals. However, while the regulations cover a wide field, there are times when it becomes necessary for an inspector to rely on his own judgment and common sense in arriving at a decision. For this reason, one should always keep an eye open for safety features and precautions while studying this text. Without some basic knowledge of the article being handled, common sense soon becomes little more than pure guess work. A study of accidents which have occurred in the handling, shipping, and storage of explosives and ammunition shows that in practically every instance where the cause could be determined, the accident has been due to circumstances which may be classed as avoidable.

There are two prime requisites which must be considered when determining a safe practice; safety for personnel, and safety for the ammunition. With respect to personnel, the inspector should be constantly on the alert to forestall any practice which might cause injury or death to any worker. With respect to ammunition, the inspector should see that it is handled, stored, and shipped in such a manner that no deterioration, damage, or destruction may result.

SAFETY REGULATIONS.

Personnel. All personnel handling ammunition should be impressed with the fact that their safety as well as that of others depends upon the intelligence and care exercised by themselves and their fellow workers.

The number of persons engaged in or around an operation should be kept at a minimum, but never should one person be allowed to carry on an operation of a hazardous nature.

Unauthorized persons should not be permitted to tamper with or disassemble any components. Serious accidents may result.

Safety shoes should be worn at any operation where explosive dust is present; particularly in the case of black powder or high-explosive operations. Safety shoes of the noninsulating type are mandatory for black powder operations.

SECTION III.

EXPLOSIVES

Chapter 1

Introduction, Military Explosives

GENERAL.

When discussing any subject, it is necessary to build up a background and most particularly a vocabulary. This is especially true of the explosives used by the Ordnance Department, since people in widely scattered establishments must communicate with each other and use commonly understood terms in their communications. It is, therefore, necessary to know some fundamental definitions:

Explosive. A gaseous, liquid, or solid substance, or mixture of substances, which upon application of a blow to a small portion of its mass, or by a rise in temperature, is converted in a small space of time into other substances more stable, which are mainly gases or vapors, but may include solids. The chemical changes thus produced result in a sudden rise in temperature and pressure in the surrounding medium.

Upon analyzing this definition, it will be found that three essential characteristics are required in an explosive. These are namely:

1. Method of initiation; flame, spark, shock, or blow.

2. Rapidity of reaction; extremely rapid.

3. Results of reaction; rise in temperature and pressure in the surrounding medium.

Any substance to be properly termed an explosive must conform to all of the above points. For example, if a small amount of sodium chloride solution were poured from one test tube into silver nitrate solution in another test tube, a white precipitate would form with great rapidity. Even though one of the conditions (rapid reaction) was fulfilled, the others were not, and thus the mixture of substances would not be considered an explosive. Also, if a small amount of hydrochloric or nitric acid were poured into a small amount of sodium carbonate solution an effervescence would be noted. Even though two of the conditions were fulfilled (a formation of gases and thus pressure if confined, and a rapid reaction), the third was not, and thus the mixture of substances would not be considered an explosive. If, finally, a small amount of black powder is ignited, all of the required characteristics of an explosive as listed above will readily be observed.

All explosives, however, are not used by the military. A military explosive may be defined as "An explosive both suitable for and used for military purposes." As an example, let us consider dynamite

or even its mother substance, nitroglycerin. Both are commonly used in industrial fields, yet neither is suitable or used for military purposes, particularly not in ammunition.

HIGH EXPLOSIVES AND LOW EXPLOSIVES.

Military explosives are divided into a class of low explosives or high explosives. These two groups differ generally in three major characteristics; namely, method of initiation, rapidity of reaction, and results of reaction. A brief chart will best serve to visualize these differences.

	Low Explosives	High Explosives
Method of initiation	Flame or spark	Blow or shock
Rapidity of reaction	Slower, deflagration	Faster, detonation
Results of reaction	Displacement, power	Shattering, brisance

It must be remembered that the comparison above is general in nature. Exceptions to any one of the generalities may be found. For example, lead azide and mercury fulminate, both commonly classed as high explosives, may be, and many times in their military uses, are initiated by flame or spark. Black powder, on the other hand, is a low explosive but may be caused to detonate if ignited while confined. Normally however, high explosives and low explosives will each exhibit characteristics in line with the above chart. Variations in normal conditions, however, can be used to cause practically any desired change in the characteristics of any one substance.

Upon being ignited, low explosives will burn rapidly, but yet slower than the reaction of a high explosive. Rapid burning of this nature, rapid combustion, the same as the burning of paper or wood although much faster, is termed deflagration.

Deflagration is a comparatively slow transformation consisting of a rapid combustion.

Low explosives as a result of their deflagration exhibit a characteristic known as power.

Power may be defined as the ability of an explosive to displace its surrounding medium.

As an example, smokeless powder in the chamber of a gun, when ignited, does not burst the gun, but displaces its surrounding medium, the only movable portion of which is the projectile. A charge of TNT in the chamber of a gun however would burst the gun. TNT is a high explosive, smokeless powder a low. This gives an insight into the probable uses of low and high explosives. Low explosives are most commonly used as propellants, while high explosives are most commonly used as bursting charges in various components of ammunition.

High explosives are normally initiated by blow or shock, either produced by mechanical means or by the explosion of a preceding high explosive in the explosive train. The high-explosive filler of a projectile, for example, is initiated by the detonation of a booster which precedes it. The booster is functioned by the shock of a detonator in the fuze which precedes it. The detonator in the fuze is initiated, perhaps, by a blow from a firing pin. Upon being so initiated, the high explosive undergoes a very rapid reaction termed detonation.

Detonation is a very rapid transformation, not instantaneous, but starting at a given point and traveling in all directions away from that point with a high but measurable velocity.

The travel of the detonation is termed the wave of detonation or the detonating wave. Its rate may be so high as to exceed even 7,000 meters per second (approx. 23,000 ft per sec). It is this extreme rapidity that causes the results of the reaction of a high explosive to differ so greatly from the results of the reaction of a low explosive. The high explosive is so rapid in its transformation that the surrounding medium is shattered. This shattering is directly related to the rapidity of the reaction. It is termed brisance.

Brisance may be defined as the capacity of an explosive upon detonation to shatter its surrounding medium.

FURTHER REFERENCES:

TM 9-2900; FM 5-25; OS 9-18, Vol. I.

Chapter 2
Low Explosives

BLACK POWDER.

Historical. The origin of black powder has been attributed by various authorities to the Chinese, the Arabs, or the Hindus. It has been proven that alchemists of medieval days were familiar, to a certain extent, with the properties of mixtures of saltpeter, sulfur, and charcoal. References to black powder may be found in history as early as 1250 A.D. Progress and development led to use of black powder as a propellant until 1870 when it replaced all other devices in use for this purpose. Today, however, its use as a propellant has been discontinued, but it retains its utility in the form of spotting charges, delay elements, and safety fuse.

Manufacture. The manufacture of black powder is not technically complicated, since black powder is nothing more than a very intimate mechanical mixture of saltpeter, sulfur, and charcoal. However, because of the great sensitivity of black powder to initiation by practically any means, unusual precautions must be observed in its

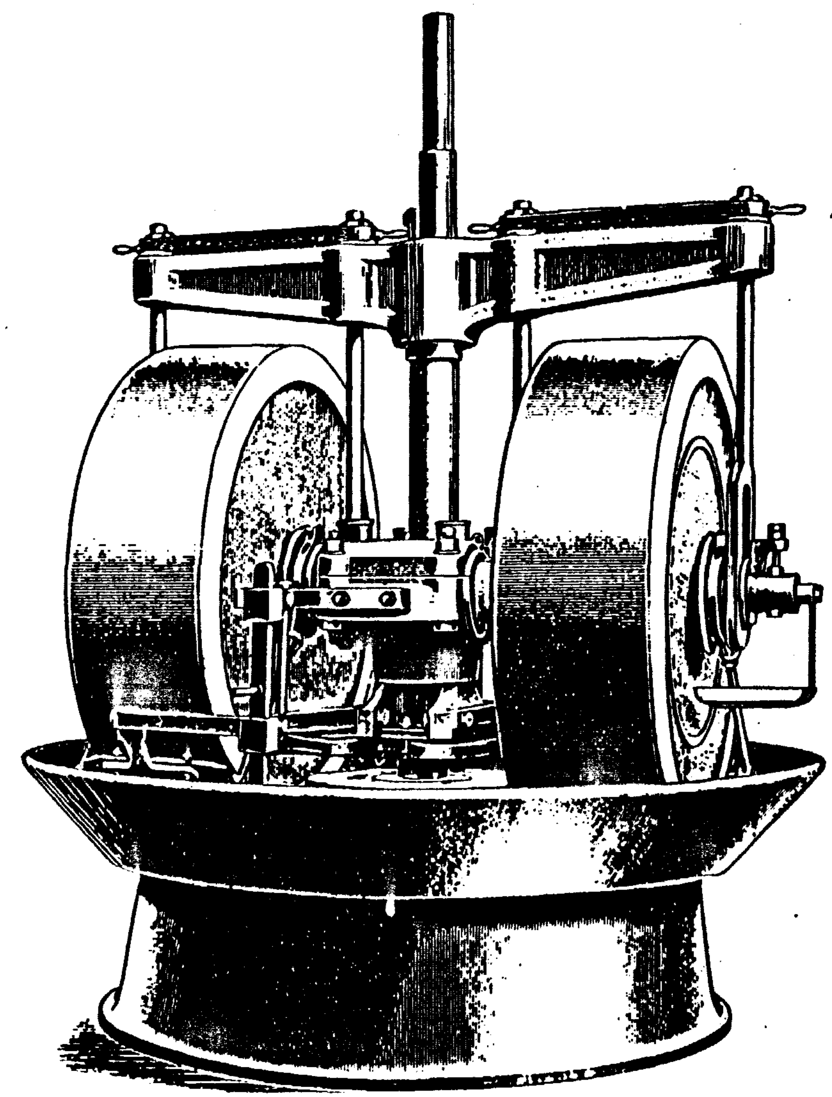


Figure 43 — Gruson Powder Mill

manufacture. A summary of the main steps in the manufacture of black powder follows:

Standard composition; 75 percent potassium or sodium nitrate, 15 percent charcoal, 10 percent sulfur.

Black powder made with potassium nitrate is known as Army black powder while black powder made with sodium nitrate is known as commercial or as sodium nitrate black powder. Sodium nitrate is commonly referred to as Chile saltpeter.

1. Pulverization and mixing. In the "wet" method of mixing, which is the most used method, the charcoal and sulfur, in the specified proportions, are pulverized in a ball mill. The ball mill is a device consisting of a revolving steel cylinder in which iron or steel balls do the crushing. The pulverized charcoal and sulfur are then stirred into a saturated solution of saltpeter at a temperature of about 130 C (265 F). The mass is then spread on a floor to cool, after which it is ready for incorporation. The lumps formed in the cooling are easily broken.

2. The edge-runner or wheel mills. After being mixed by the above method, the material is spread on the bed plate of a wheel mill. The wheel mill consists of two cast iron wheels, with nonsparking plows of phosphor-bronze. These wheels revolve on an axle, which in turn rotates about a central axis, the wheels rolling on the bed plate of the wheel mill. The wheels are in contact with the bed plate if it is wooden, but are suspended slightly above it if the bed plate is of cast iron. A safety device is included which consists of independent suspension of the wheels permitting an upward movement to prevent violent crushing of any possible lumps. The wheels weigh from 5 to 8 tons each. The plows are set in opposite directions, the plows on the inner wheel throwing the material to the outside, the plows on the outer wheel throwing the material to the inside. The process is carried on for about 3 hours at 10 rotations per minute. Water is added to maintain 3 to 4 percent water content (safety precaution). A wheel cake or clinker which forms must be broken before the next operation. The wheel mills thoroughly mix the ingredients, insuring a close mechanical contact between the ingredients.

3. Pressing. In order that the powder exhibit uniformity of ballistics, it is necessary that it be of uniform density. To achieve this uniform density, the mix from the edge-runner mills is placed on aluminum press plates which are then stacked on a small trolley. The trolley is then run over the bed plate of a vertical hydraulic press. A pressure of 1,200 pounds per square inch is applied and held for varying lengths of time. Cakes about ¾ inch thick by 24 inches square are the result. These cakes are broken with wooden tools and transported to the corning mills.

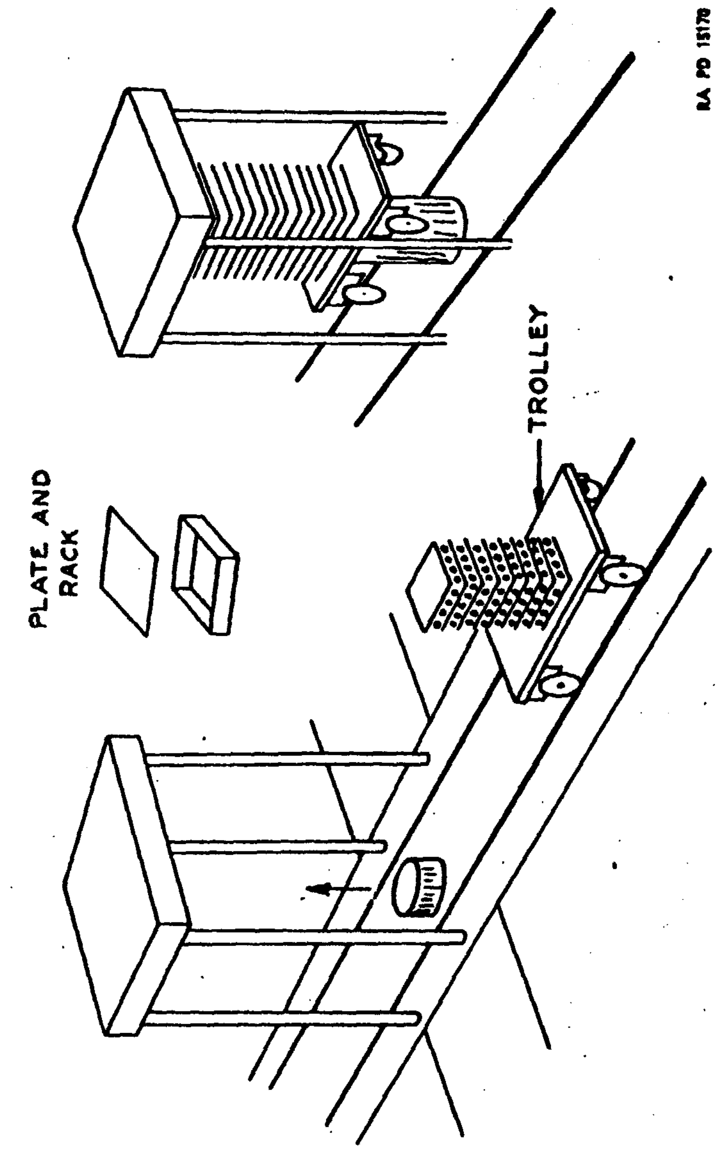


Figure 44 — Pressing Operation

4. The corning mills. The press cake is cracked or granulated in the corning mill by feeding the cake between crusher rolls. Mechanically-operated shaking screens separate the dust and coarse grains from the finished grains; the coarser lumps pass through successive crushing rolls, four sets of crushing rolls being the usual number per mill. The dust is generally passed back to the edge-runner mills but may also be used as meal black powder. The corning operation is considered the most hazardous of the various operations in the manufacture of black powder. Many devices, of which the following are typical, have been employed to reduce the loss of property and life in the corning mill to a minimum:

One of each set of crusher rolls is held by springs so that the roll may give, rather than violently crush extraordinarily hard lumps.

The broken press cake is fed to the corning mill by a conveyor which passes over the top of a steel barricade.

All personnel are excluded from the building during the operation.

5. Finishing. Rounding or polishing the grain is accomplished by tumbling in a revolving wooden cylinder. Drying is generally accomplished by forcing a current of warm air through the cylinder while the powder is being polished, or the powder may be removed from the cylinder and dried in stationary wooden trays. To glaze the grains, a small quantity of pulverized graphite is added to the powder while the powder is warm from the tumbling process and the process is continued for about a half hour. The drying and glazing process, when carried out on the single operation plan, requires approximately 8 hours.

Grades and Uses. Army black powder.

Composition: potassium nitrate, 75 percent; charcoal, 15 percent; sulfur, 10 percent.

Grade A.

Glazed.

No. 1. Igniting charges, certain primers, saluting charges.

No. 2. Unassigned.

No. 3. Special uses.

No. 4. Base charges for shrapnel, base charges for fuzes, primers, smoke-puff charges, bursting charges for practice projectiles, bursting charges for certain subcaliber shell, and spotting charges for practice bombs.

Unglazed.

No. 5. Pellets for primers and fuzes.

No. 6. Pellets for primers and fuzes.

Meal or fuze powder. Loading time train rings.

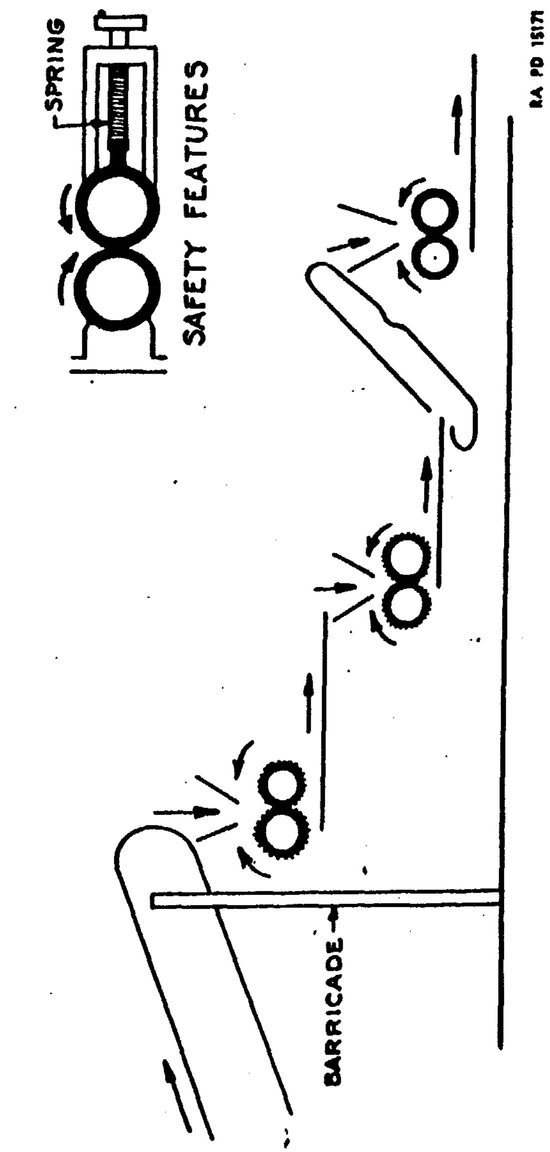


Figure 45 — The Corning Mills

Classes and Uses. Sodium nitrate black powder.

Composition: sodium nitrate, 75 percent; charcoal, 15 percent; sulfur, 10 percent.

Class A; saluting charges.

Class B; spotting charges for practice bombs.

Both the above grades are based on granulation, for Army black powder grade A, No. 1 is the coarsest granulation and meal or fuze powder the finest. For sodium nitrate powders, Class A is the coarser and Class B the finer.

The sodium nitrate black powder is more hygroscopic than the potassium nitrate black powder, and therefore is used where absolute dependability is not required.

Control of the Burning Rate of Black Powder.

To slow the rate.

1. Compress the powder into pellets, time train rings, or other devices.

2. Increase the charcoal content at the expense of the nitrate content.

3. Increase the sulfur content at the expense of the charcoal content. (Note—lessens the uniformity of the burning rate.)

4. Incorporate adulterants such as red or white clay. (Note—absorption of moisture acts as an adulterant.)

5. Substitute other nitrates for potassium nitrate. Barium nitrate is sometimes used for this purpose.

6. Substitute hardwood (oak) charcoal for softwood (willow or alder) charcoal.

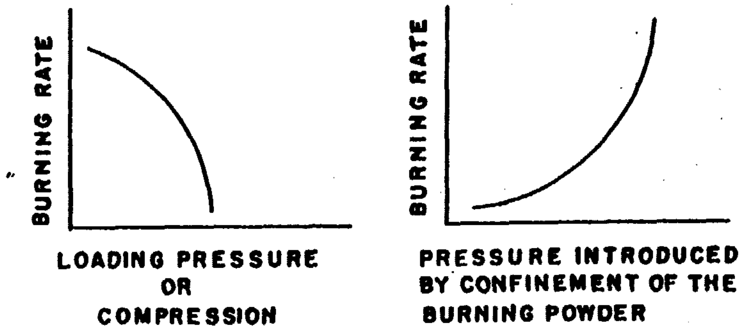
7. Substitute coal (powdered) for charcoal.

To speed the rate.

1. Confinement of burning black powder speeds the rate of burning. In some cases detonation may result. (Note—speed is not desired but must be considered.)

Comparison of effect of confinement and compression. By virtue of its method of manufacture black powder has a porous structure. Therefore, if the powder is compressed into pellet form, the porosity is lessened and the penetration of hot gases into the interior of the pellet is hampered, thus reducing the burning rate. On the other hand, if the powder is burned in confinement (or as a result of greater than atmospheric pressure), the penetration of hot gases into the interior

of the grain will be enhanced. This will result in a faster rate of burning and a quicker consumption of the grain.



RA PD 15172

Reasons for Discontinuance of Use of Black Powder as a Propelling Charge.

1. Flash and smoke of discharge too great, revealing gun positions day and night.

2. Intense heat and violent pressure developed during discharge caused excessive erosion of the gun barrels.

3. Solid residue or ash left in the chamber after combustion proved dangerous to loading of succeeding charges, particularly in the case of separate loading ammunition.

4. Rate of burning difficult to control. Control of burning rate is essential for uniform ballistics.

5. Unstable in storage; it is hygroscopic. Absorbed water acts as an adulterant and slows the burning rate.

6. Dangerous to handle. Black powder is easily initiated by spark, flame, friction, and other means.

Products of Combustion of Black Powder.

Gaseous—44 percent Gaseous Products percent by volume		Solid—56 percent Solid Products percent by weight	
CO_2—carbon dioxide	49.0	K_2CO_3—potassium carbonate	61.0
CO—carbon monoxide	12.5	K_2SO_4—potassium sulfate	15.0
N_2—nitrogen	33.0	K_2S—potassium sulfide	14.5
H_2—hydrogen	2.0	S—sulfur	9.0
CH_4—methane	0.4	KCNS—potassium sulfocyanide	0.2
H_2S—hydrogen sulfide	2.5	KNO_3—potassium nitrate	0.3
H_2O—water vapor	0.6		

Uses of Black Powder.

1. Miners safety fuse which is composed of a core of compressed black powder enclosed in an insulated wrapping. It burns at a rate of 32 to 40 seconds per foot. It is recognizable by its smooth, white, outer wrapping.

2. Instantaneous blasting fuse which is a core of loose black powder enclosed in an insulated wrapping. No delay is imposed on the rate of burning. It is recognizable by its welted or braided red outer wrapping.

It is necessary, in order to achieve maximum safety, to burn an experimental length of about 1 foot of the fuse being used to determine its burning rate. One can easily see the danger or hazard coincident with mistaking instantaneous fuse for safety fuse.

It will also be noted that there are two spellings for the word fuse (fuze). By common practice in this country, the word "fuze" is applied to a mechanical device for producing explosion or detonation in artillery projectiles, bombs, or grenades, while the word "fuse" refers to the cord or casing filled with black powder or high explosive such as is used in blasting and mining work for setting off charges of explosive.

At the present time, any stocks of instantaneous fuse, not the property of the engineers, on hand in depot storage should be destroyed. Stocks which are engineer property should be marked with a red tag for issue only as directed by the Chief of Ordnance. Such issue will be for experimental purposes or to meet special situations.

Black Powder Charges. The assembly of blank ammunition for cannon and assembly of saluting charges will be conducted in accordance with special instructions furnished by the Chief of Ordnance.

Blank ammunition may be loaded with either:

1. Army black powder in bags.

2. Sodium nitrate black powder in bags.

3. Sodium nitrate black powder in pellet form.

Sodium nitrate black powder is available commercially and at a cost somewhat less than Army black powder, which contains potassium nitrate. Commercial sodium nitrate black powder pellets wrapped in cellophane are being used extensively. The pellet form of this powder greatly facilitates loading and reduces assembly hazards. Pellets are supplied in single and double units for reduced and full charges, respectively. Because sodium nitrate black powder is more hygroscopic than Army black powder, additional care is necessary in storing and handling, to prevent exposure to moisture.

Precautions similar to those applying to the assembly of other ammunition will be followed in assembling blank ammunition and saluting charges. Particular caution must be exercised because of the treacherous nature of black powder. The following general safety regulations will be complied with in the assembly of blank ammunition and saluting charges:

1. Black powder operations should be conducted in special buildings, which will not be used for other purposes at the same time.

2. The floor of the building in which black powder is handled will be surfaced with suitable material.

3. Intraplant quantity-distance requirements for high explosives as given in the Ordnance Safety Manual will be followed.

4. Absolute cleanliness will be maintained at all times in and around each operation.

5. Noninsulating safety shoes will be worn by personnel in all assembly operations.

6. All equipment will be electrically grounded, and it should be determined by test that all parts of the equipment are effectively grounded.

7. Empty metal containers which have held black powder will be thoroughly washed inside with water before they are disposed of. Serious explosions have occurred with supposedly empty cans. Wooden containers will be destroyed by burning.

8. Safety tools only will be used in opening or closing containers or in handling black powder.

9. Processes should be so laid out as to bring about frequent grounding of operators.

Packing and Marking. The standard container for Army black powder is a metal keg of 25-pound capacity built in accordance with ordnance specifications, or a commercial drum of equal quality and capacity complying with Interstate Commerce Commission regulations.

Black powder in the form of igniting charges may be packed in airtight, metal-lined containers, complying with Interstate Commerce Commission regulations; but the amount of black powder packed in one container is limited to 50 pounds.

In addition to the marking prescribed by Interstate Commerce Commission regulations, the following identifying data should appear on Army black powder containers: ordnance contract number; manufacturer's name; plant symbols or key letter; name and grade of material; army lot number; net weight and gross weight.

Storage and Shipping. Ordnance drawings show the recommended method of piling black powder in metal containers. This method will be followed when new stocks are received or existing stocks are repiled.

Present ordnance drawings recommend storage of black powder metal containers with longitudinal seams on the side, with lip down so that moisture will drop off rather than run into the seam. This is in a pyramided stack. It is suggested, that since rusting occurs at points where the metal cans contact each other, that a pile built up with battens between each layer will afford better protection against moisture. The use of separators on the battens to prevent even a side contact of the cans may be found effective. It should be noted that this is a suggestion. There is no present authority for storage in this manner.

When black powder is shipped or received, each container will be inspected for holes, such as those made by nails, which are visible only upon close examination. Damaged containers will not be repaired; the contents will be transferred to new or serviceable containers.

Metal containers for export shipment will be crated. Usually two containers are packed in each crate.

Surveillance. Since black powder deteriorates with the absorption of moisture, and the cans in which it is stored are subject to rust, a thorough inspection of this material in storage will be made at least once each year. One or more containers from each lot will be opened at the time of the annual inspection, and if there is any doubt as to the serviceability of the powder, the Chief of Ordnance will be notified of the existing conditions.

Maintenance. Repainting of containers and repacking of black powder contained in damaged or unserviceable containers constitute the principal maintenance activities. Black powder containers are subject to condensation of moisture, which rusts metal drums or kegs, so repainting is necessary to keep containers serviceable. Repainting will not be done in a magazine in which explosives or ammunition are stored. It may be done in a nearby empty magazine, or in clear weather in the open at least 100 feet from the nearest magazine. The quantity of black powder at or near such operations will be limited to 100 pounds. The marking on repainted containers will be checked carefully to see that it is a facsimile of the old.

The metal caps on certain types of black powder containers deteriorate in storage. Replacement of these caps is allowed, but the same safety precautions as outlined above for repainting containers will be followed.

Operations such as the removal of black powder from containers and its transfer from unserviceable to serviceable drums will be conducted in strict compliance with applicable portions of the safety regulations for black powder charges, as described in the following paragraph.

Fires. Most black powder fires start from sparks, and ignition results in an explosion so quickly that no attempt can be made to fight the fire. Every effort will be made to prevent fire from reaching stores of black powder, but if this fails, fire-fighting forces will be withdrawn at least 800 feet from the fire, and will protect themselves

against an explosion by seeking any cover available, or by lying flat on the ground.

If an explosion should occur, every effort will be made to prevent flames from spreading to adjacent mazagines. Fire-fighting forces must be cautious in approaching a fire which may involve black powder to avoid being trapped or injured by an explosion.

Safety Precautions. Black powder is regarded as one of the worst known explosive hazards. When ignited unconfined, it burns with explosive violence, and will explode if ignited under even slight confinement. It can be ignited easily by very small sparks, heat, or friction.

Most explosions of black powder originate from sparks, and the safety rules contained in the following paragraphs will be strictly enforced and obeyed.

A container will not be opened in a magazine in which explosives or ammunition are stored. This will be done only in a room or building free from all other explosives or ammunition, or in suitable weather in the open at least 100 feet from the nearest magazine. The quantity at or near such an operation will be limited to 100 pounds.

Safety tools only will be used in opening or closing containers, or in other operations involving black powder.

Safety shoes will be worn in all rooms in which black powder is handled, and by all persons engaged in handling black powder; the wearing of nonconductive shoes such as rubber is prohibited.

If the handling of black powder is carried on over a concrete floor, the floor will be covered with a tarpaulin, or other suitable material.

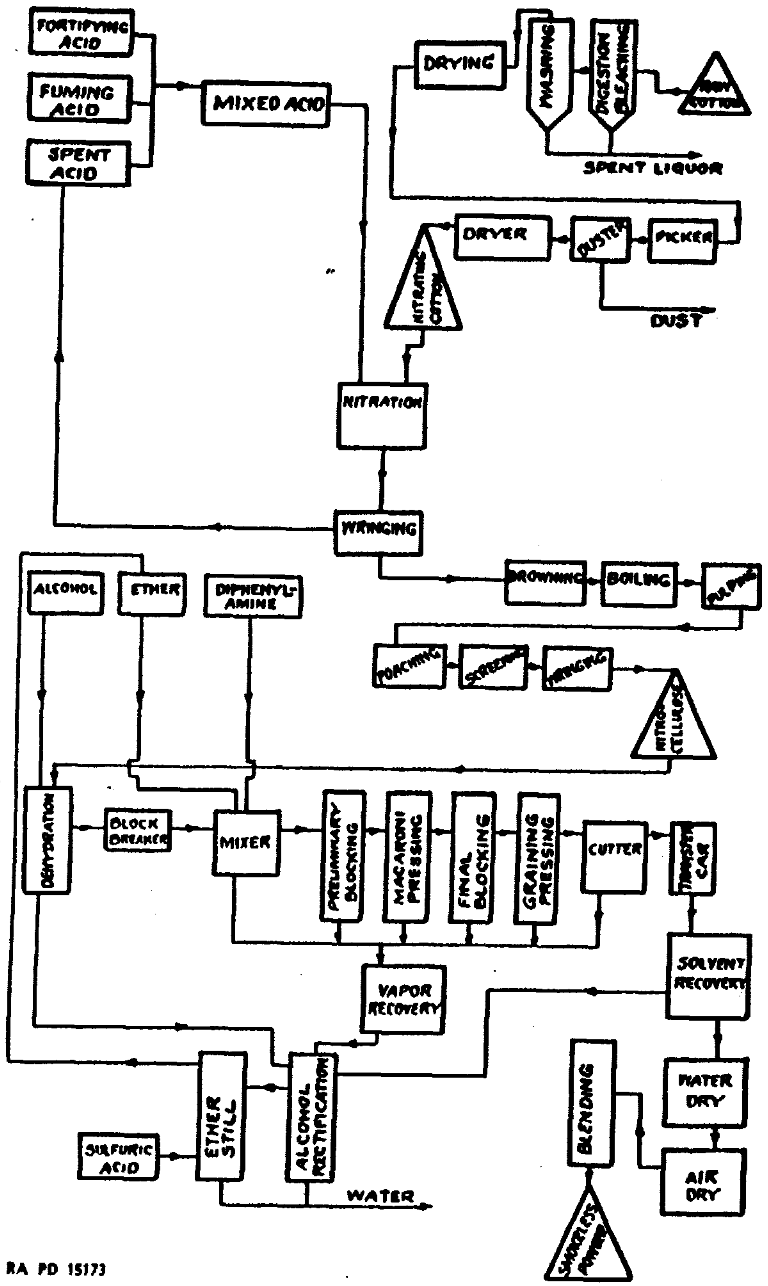
Loose black powder is extremely dangerous. Whenever it is necessary to handle loose black powder, not over 50 pounds of powder in open containers and 50 pounds in closed containers (100 pounds, total) will be permitted at or near such operations.

If black powder is spilled on benches or floors, all work will be stopped until the powder has been removed and the explosive hazard of any remaining dust or fine particles has been neutralized with water.

Rooms or buildings in which black powder is handled will be inspected frequently for the presence of black powder dust; and all such dust will be immediately removed with water.

SMOKELESS POWDER.

General. Smokeless Powder is considered in this chapter because of its succeeding black powder as a propellant. There are so many variations in the rate of burning of the various granulations and formulas of smokeless powder that it should be considered as a



RA PD 15173

Figure 46 — Flow Sheet — Manufacture of Smokeless Powder

class 2 explosive, except as noted under "Fires," below, with hazards largely limited to combustion with intense heat, rather than as a true low explosive.

In the latter part of the nineteenth century, smokeless powder of various forms was considered for use as a propellant. Its rapid development toward this end soon led to its replacing black powder for this use. At present, smokeless powder is the only propellant used. Its many advantages over black powder as a propellant include: accurately controlled burning rate; it is nonhygroscopic; it produces much less flash and smoke when fired; and it is much less hazardous in handling and storage.

Manufacture. The manufacture of smokeless powder may be considered as the result of eight major steps. These steps are best explained by the following outline:

I. PURIFICATION OF THE RAW COTTON.

A. Digestion. The purpose of this step is to remove the vegetable oils, resins, and other extraneous material in the cotton.

1. Cook. 6 hours, 2 percent caustic soda solution at 72 pounds per square inch pressure and 152 C temperature.

2. Wash. With water.

3. Bleach. A 2½ percent solution of commercial bleach for as short a time as is necessary to decolorize. 36 C.

4. Excess bleach is destroyed with sulfuric acid.

5. Wash and dry.

B. Picking. If uniform nitration is to be obtained, it is essential that the cotton be of uniform low moisture content, or uniform physical condition, and free from lumps or other extraneous materials. The picking process and the drying process, which follows it, together achieve this uniformity of condition.

1. Picking machine. Cotton torn apart and fluffed by toothed rollers revolving at 1,000 revolutions per minute.

2. Air-blast. Cotton blown through flues and past baffles to the dry house. The baffles separate the fibers from the dust which settles into elbows or traps in the flues.

C. Dry House. Entering cotton contains about 8 percent of moisture. Treatment reduces this to about 0.5 percent.

1. Continuous drier. Cotton carried by conveyor through a long chamber heated to about 100 C. Weighted directly from belt into containers for transportation to dry house.

2. Chamber drier. An alternative method, more costly and less economical of time. The cotton is placed in long chambers which are tightly closed and heated to 105 C by a hot air blast. The time for a 2,500-pound charge is 24 hours. The end of the process is indicated by a laboratory test of the cotton showing a moisture content of less than 1 percent. Cotton transferred in fiber containers, carrying 32 pounds each, to the nitrating house.

II. NITRATION OF THE PURIFIED CELLULOSE.

A. Systems Used. DuPont mechanical dipper. Centrifugal. Thompson displacement. Pot.

1. The DuPont mechanical dipper process is the most frequently used because it is more economical of time, and also because the fumes are negligible.

The nitration. Four iron or stainless steel nitrators arranged for handling from a central point. Charge per nitrator is 1,500 pounds of mixed nitric and sulfuric acid and 32 pounds of cotton. The temperature of the acid is about 30 C. The cotton is drawn beneath the acid charge by vertically revolving paddles revolving at 60 revolutions per minute. Nitration continues for 24 minutes after which discharge valves in the bottom of each nitrator are opened dropping the nitro cotton and acid into centrifugal wringers below each nitrator.

The centrifugal wringer is a device, similar to a centrifuge, which rotates at first slowly at 300 revolutions per minute and later as fast as 1,100 revolutions per minute. This latter rate is held for 3½ minutes. The cotton is forked from the wringer into an immersion vessel below, from whence it is pumped or transferred by gravity to the boiling tub house. The heavier acid has been whirled off into catch basins where small residual amounts of nitrocotton are allowed to settle out.

III. PURIFICATION OF THE NITRATED CELLULOSE.

A. The Preliminary Boiling. The purpose of this step is to remove lower nitrated bodies and other impurities. The first boil lasts 16 hours, and is done in a solution of 0.1 to 0.3 percent sulfuric acid. Three neutral water changes are then made, the second and third coming at 8-hour intervals. The entire process consumes 40 hours.

B. Pulping. The purpose of this operation is to macerate the fibers of the nitro cotton in order to liberate free acid absorbed within the fiber. Also a finer state of division is obtained. The Jordan engine used in this process is a conical rotor in which are set broad bladed knives. These knives macerate the fibers as they are pushed through by a large volume of water. The desired degree of fineness is indicated by a clean break of a squeezed dry handful of material. Actual fineness is shown by laboratory test.

C. Poaching. The purpose of this process is to neutralize the acid liberated during the pulping process. It is similar to the preliminary

boiling except that it is carried out in a first water which is alkaline rather than acidic. The solution of first water is made up by dissolving 1 pound of SODA ASH (sodium carbonate) to a gallon of water. Seven and a half gallons of this solution are used to every 3,000 pounds of dry nitrocellulose. The other waters used are neutral and there are four rather than three changes. Ten cold water washes conclude the process.

D. Tests. At this stage of the process, various tests are performed on the nitrocellulose to indicate various properties which are of importance to later steps in the process. It is tested for:

1. Stability of the pyrocotton by KI test (potassium iodide and heat test at 134.5 C).

2. Percentage of nitrogen in the pyrocotton.

3. Solubility of the pyrocotton in the ether-alcohol mixture.

4. Degree of fineness.

5. Ash.

E. Screening. The purpose of this process is to remove any lumps or foreign materials. It is carried out in a Packer screen which is a brass plate having slits 0.025 inch wide. The pyrocotton is drawn through the slits by suction. Lumps are returned to the pulping process.

F. Wringing. The purpose of this process is to remove mechanically the larger amount of water present in the pyrocotton so that the dehydration with alcohol is accomplished with the minimum amount of water present. The wringer is a perforated brass basket lined with 24-mesh screen. This is revolved at 950 revolutions per minute for about 7 minutes. The moisture content will average 26 to 28 percent after this process.

IV. FORMATION OF THE COLLOID.

The purpose of this step is to put the nitrocellulose in a form in which its ballistics can be controlled.

A. Dehydration. The nitrocellulose as it leaves the previous step contains about 28 percent of moisture. The dehydration process removes this moisture and leaves in its place the required amount of alcohol solvent. The nitrocellulose is placed in a hydraulic press, and a pressure of 250 pounds per square inch is applied to squeeze out a portion of the excess moisture. One and a quarter pounds of alcohol per dry weight pound of nitrocellulose is then added under pressure and the pressure in the press is raised to 3,500 pounds per square inch. The first portion of alcohol combines with residual moisture and is forced out leaving a block practically free of moisture. The remaining portion is that amount of alcohol necessary as a solvent

B. Breaking. The dehydrated block of nitrocellulose from the press is broken up to enhance the next process. The block is broken by being thrown against prongs and wire screens in a rotating drum. This produces small lumps which readily lend themselves to the mixing process.

C. Mixing. At this point, the ether necessary as a solvent for formation of the colloid is added. In solution with the ether is the diphenylamine necessary as the stabilizer. The finished powder will contain 0.9 to 1.10 percent diphenylamine. The mixing is accomplished in a water-cooled tank in which agitators rotate in opposite directions, thus kneading the material in the mixer. The ether is poured in rapidly to minimize evaporation, and the material is kept in closed containers from this point onward, for the same purpose.

D. Pressing. The mechanical action of three pressing operations completes the formation of the colloid.

1. The preliminary blocking press. Hydraulic press similar to the dehydrating press. The material is formed into a cylindrical block at 3,500-pound per square inch pressure.

2. The macaroni press. The block from the previous process is run through one 12-mesh-per-inch steel plate, two 24-mesh-per-inch steel screens, and one 36-mesh-per-inch steel screen at a pressure of 3,500 pounds per square inch.

3. The final blocking press. The material is again formed into a cylindrical block at a pressure of 3,500 pounds per square inch in a press similar to the preliminary blocking press. The colloid has now changed its appearance from a mass resembling light brown sugar to a dense, elastic, translucent brown or amber substance.

V. GRAINING AND CUTTING.

The granulation of the powder is one of the major factors in control of the burning rate. The block of colloid from the previous process is forced in horizontal or vertical hydraulic presses through steel dies. The press head may be equipped with 1 (16-in. gun powder) to 36 (small-arms powder) dies. The material issues from the press in strands which are led over pulleys to the cutters. The cutters are finely adjusted and control the length of the grain very closely.

VI. SOLVENT RECOVERY.

An excess of solvent is used to enhance formation of the colloid. The solvent recovery process removes the greater portion of this excess. The equipment used for this process varies but the cycle of operations is the same in all cases. Warm air is circulated through the powder in a closed chamber, and then passed over cold condenser coils where it loses the solvent it has picked up. The cycle is re-

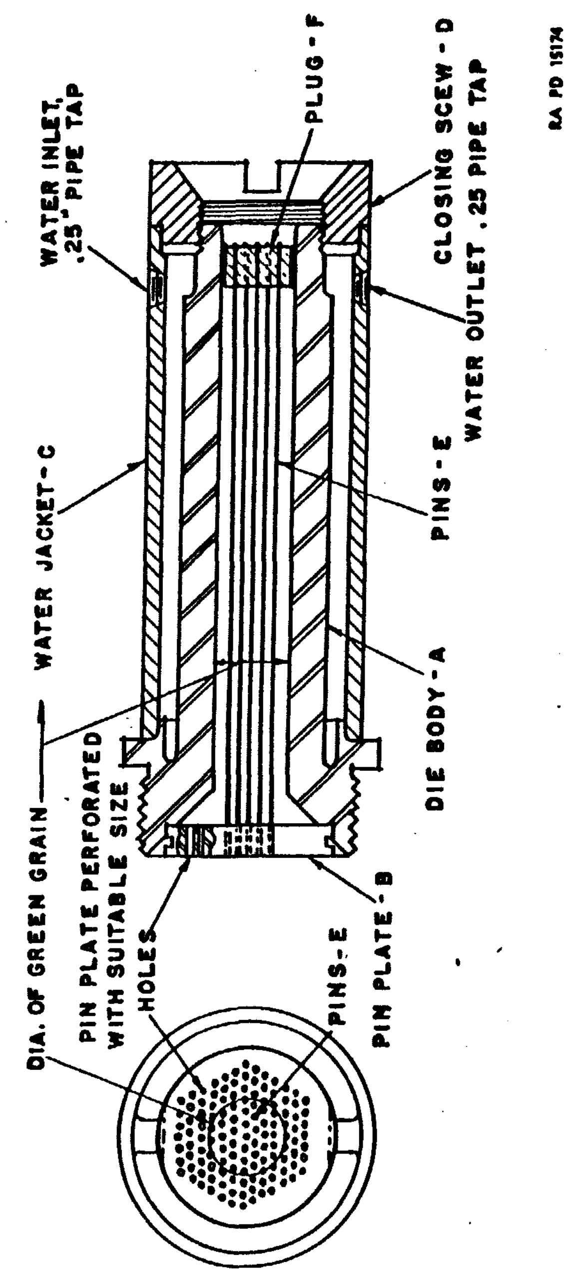
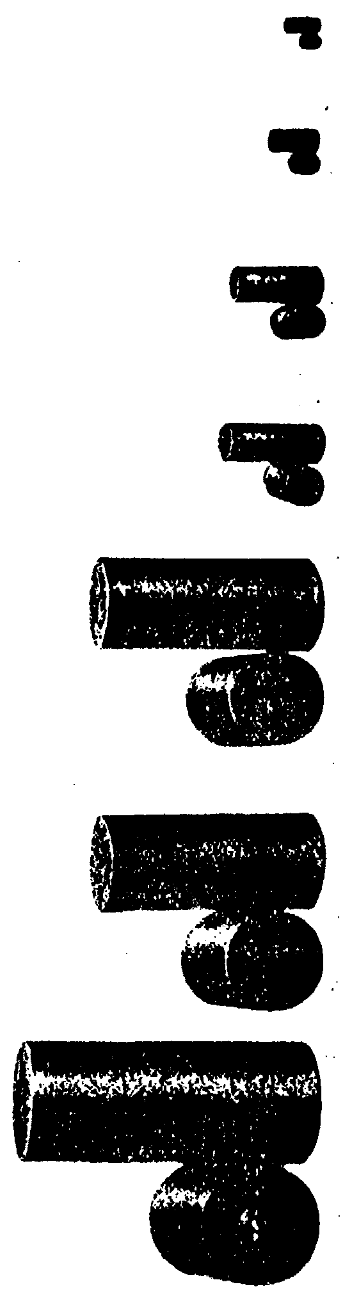


Figure 47 — Powder Die Assembly for Cylindrical Grains



RA PD 4413

Figure 48 — Typical Powder Grains

peated as long as necessary; large calibers requiring a greater length of time than smaller calibers. The rate of recovery is carefully controlled in order that an even removal of solvent will be obtained, and in order that shrinkage may be controlled.

VII. DRYING.

A certain amount of solvent is retained in the powder by specification as an additional factor in control of the burning rate. The drying process removes residual solvent to this point. It is more finely controlled than the solvent recovery process. Three processes are in use.

A. Air-dry. The most satisfactory from standpoint of stability. The powder is placed in bulk in narrow bins and subjected to heat. The time necessary to drive off the required amount of solvent, and the necessary temperature increases with larger calibers of powder. Laboratory test of samples indicates the end of the process. Control is essential since increase in percentage of retained volatiles reduces the rate of burning and the energy content of the powder. Thirty to 90 days are usually necessary.

B. Water-dry. The most satisfactory from the standpoint of time consumed. Warm water is circulated through the powder at a temperature of 25 C to 55 C. The powder after a few days of this treatment is air dried for another few days. The moisture content will, of course, be higher than that of air dried powders.

C. Continuous-dry. The powder is slowly run through a chute as warm air is passed through it. Baffles in the chute retard its progress. A shaking device controls the rate of progress. This process is most economical of time, and is also satisfactory from the standpoint of stability and fineness of control. 100,000 pounds of 75-mm powder may be dried by this system in 24 hours.

VIII. BLENDING.

In order to obtain uniformity of ballistics, lots of powder are thoroughly mixed or blended. This blending insures that all charges manufactured from a lot of powder will have similar ballistics. Lots range in size from 15,000 to 50,000 pounds for small arms and minor calibers to 100,000 pounds for larger calibers. The operation consists of transferring the powder by gravity from an upper to a lower bin. A baffle fans out the powder and insures proper mixing. A continuous cycle is the most recent development. Two buildings are placed 100 feet apart, each with upper and lower bins. Powder is transferred by conveyor belt from lower bins of one to upper bins of the other. Four complete cycles complete the blending. The powder is weighed into storage containers from the blending operation.

Disadvantage of Early Nitrocellulose Powders. The straight nitrocellulose or NC powders, if exposed to the atmosphere, were subject to change. Exposure to a humid atmosphere will cause absorption of water and a resultant reduction in the rate of burning and in energy. It will also cause deterioration of the powder by hydrolysis. As previously stated, the ether-alcohol solvent is not entirely removed, but is allowed to remain in percentages ranging from 3 to 7.5 percent for purpose of controlling ballistics. If the powder is exposed to a warm dry atmosphere, this residual solvent will escape with a resultant increase in the burning rate and energy of the powder. Ballistics will thus be affected.

Another objection to the NC powder was the large, brilliant muzzle flash produced upon firing. This flash aided the enemy in locating gun positions during night firing. The flash was caused by unburned propelling charge gases meeting the outside air at kindling temperature. Ignition and muzzle flash resulted.

Materials Added to FNH and NH Powders.

Diphenylamine (D.P.A.). This substance stabilizes the smokeless powder by combining with nitrous fumes given off as a result of deterioration. When nitrocellulose reacts with water, it hydrolyzes and reverts back to cellulose and free acid. The free acid is given off in the form of acidic gaseous oxides of nitrogen. The presence of these acidic fumes causes acceleration of the deterioration. The reaction builds up heat as it progresses until finally the kindling temperature of the nitrocellulose is reached and spontaneous ignition results. Diphenylamine by chemically combining with the acidic fumes prevents this acceleration of reaction as long as any of it remains present and uncombined. It thus prolongs the stable life of the powder.

Dibutylpthalate (D.B.T.). This substance is used as a cooling agent and as an inhibitor of hygroscopicity. It is an oily viscous liquid and is inert in the explosive sense. Since it is inert explosively, it cools the gases from the propelling charges below their kindling point and thus prevents muzzle flash when they reach the outside air. Since it is oily and viscous, it acts to sheer off water and thus overcomes the hygroscopic tendencies of the nitrocellulose. It is added during the mixing process of the formation of the colloid and replaces a portion of the volatile solvent necessary to the old NC powder. In this way, it reduces the percentage of volatile constituents present and thus the possibility of loss of volatile ingredients.

Dinitrotoluene (D.N.T.). This is used as a coat on certain small-arms powders to control the burning rate. Used as dinitrotoluene oil in larger calibers, it aids in reducing hygroscopicity. In reducing percentage of volatiles present, and being explosive in nature to a certain extent, it compensates, to a degree, for the loss in potential caused by incorporation of the explosively inert dibutylpthalate.

The terms FNH and NH are related to the caliber of weapons in which the powder is used. As weapons increase in caliber, the powder charge also increases, and at a rate in excess of the increase in length of gun barrel. In larger weapons, therefore, not enough D.B.T. can be added to cool unburned gases before they reach the muzzle of a comparatively shorter barrel, as related to the increase in weight of the charge. Generally speaking, FNH and NH powders have the same composition, the flashlessness depending upon the weapon in which the powder is used.

The potential of FNH and NH powders is somewhat lower than that of NC powders due to the addition of the inert cooling agent. However, it is not so much lower that the FNH and NH powders cannot be used in the same weapons as the NC powders without modification of the weapons.

Control of Burning Rate of Smokeless Powder. Three fundamental factors influence the burning rate of smokeless powder. These will best be considered individually:

1. Size and shape of grain. The rate of burning of a grain of powder is said to be degressive when the burning surface of the grain is reduced as the grain consumes itself. This results in the intensity of burning, and thus the amount of gases produced, lessening continually as the grain is consumed. Grains which exhibit a degressive rate of burning include strip, cord, and monoperforate types (fig. 49).

Conversely, the rate of burning is said to be progressive when the burning surface of the grain increases as the grain consumes itself. This results in the burning rate, and thus the amount of gases produced, increasing continually as the grain is consumed. Progressive burning is exhibited by multiperforate rosette or multiperforate cylindrical grains (fig. 49). It will be noted that perforated grains have either one or seven perforations. There are no intermediates.

When the multiperforate cylindrical grain burns, slivers which burn degressively are formed as the perforations enlarge through burning and meet the decreasing outer surface. In such weapons as the 12-inch seacoast mortars the barrel is not sufficiently long to allow complete burning of these slivers, and they are thus expelled from the muzzle in the unburned state. To reduce the amount of powder thus wasted, the sliverless grain was developed. This is commonly known as rosette (fig. 50).

2. The percentage of volatile and inert ingredients and retained moisture. The moisture retained in smokeless powder acts as an adulterant in the same way as it would in black powder. That is, it slows the burning rate and reduces the energy of the powder. The moisture reduces the energy of the powder and its rate of burning directly. For example, if a powder of 100 units of nitrocellulose has an energy

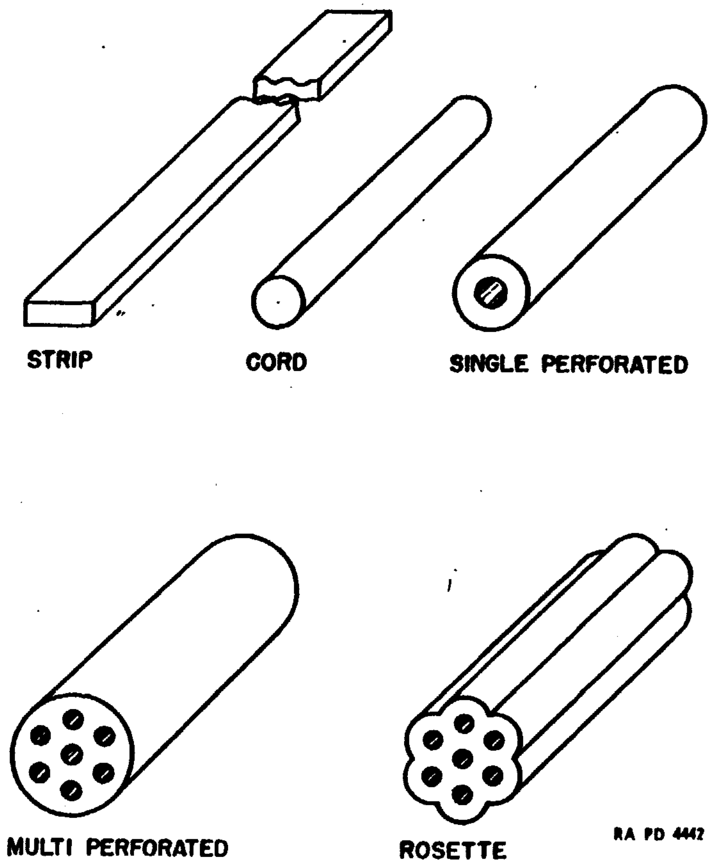


Figure 49 — Forms of Powder Grains

of 100, a powder of 99 units of nitrocellulose and one unit of moisture will have 99 units of energy.

Alcohol, ether, diphenylamine and other carbon and hydrogen compounds have a greater effect than does moisture because they utilize some of the energy of the powder to burn themselves. Their effect, if the effect of water is taken as one, would be as follows:

Water	1.0
Alcohol	2.5
Graphite	2.5
Diphenylamine	4.0

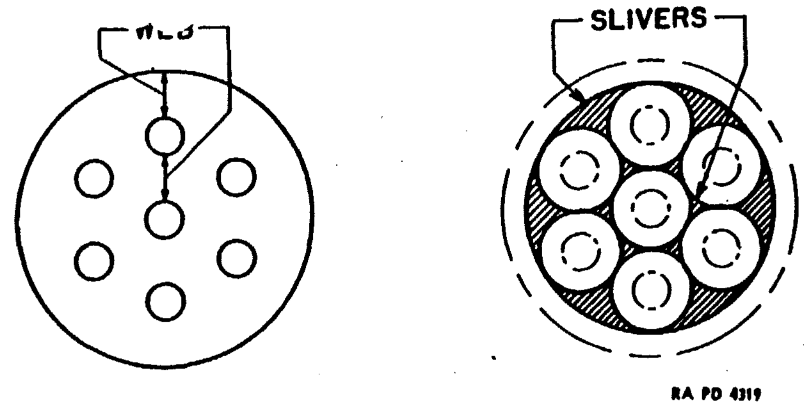


Figure 50 — Burning Grains

Other substances of like nature would influence the energy of powder in ratios corresponding to their carbon content and the readiness with which they will take part in the reaction.

3. The web average. The web of a powder grain is defined as the least burning thickness between parallel surfaces on a diameter. This factor is used as a control of the burning rate of multiperforate grains. As shown by the diagram (fig. 50), these grains will have two webs, an inner and an outer web. The web average is an average of these webs as shown. Powders having a thicker web are slower burning, and powders having a thinner web are faster burning.

Generally speaking, web thickness increases with caliber. However, shorter barreled weapons such as the howitzer and mortar will require thinner webs to achieve complete burning. Also, the larger the capacity of the powder chamber, the thicker the web of the grains.

Final Dimensions Factors in Design of Powder. Generally speaking, the weight of the projectile effects the design of powder since the heavier the projectile the thinner is the web required, consistent with the maximum chamber pressure.

Also, the greater the velocity desired the thicker is the web required, consistent with the maximum chamber pressure.

The maximum chamber pressure of any weapon is a constant. Therefore, an increase in weight of the projectile or an increase in velocity will require a slower burning powder, or in other words one of thicker web.

Causes of Deterioration in Smokeless Powder. Moisture causes hydrolysis of nitrocellulose with the evolution of nitrous fumes. Presence of fumes will cause acceleration of the deterioration, a building up of heat, and finally spontaneous ignition of the powder.

A specified percentage of volatile solvents and moisture is allowed to remain in the finished powder as a control of burning rate. Any change in this content will result in a change in ballistics, thereby making the powder useless from a ballistic standpoint.

Heat will accelerate any chemical reaction. Moisture and heat will, therefore, cause the powder to deteriorate more quickly than moisture alone.

Smokeless powder is kept in airtight containers. Fluctuating temperatures to extremes set up expansions and contractions which may cause leaks in the containers, and thus allow moisture to enter and volatiles to escape.

Packing and Marking. Smokeless powder is packed in accordance with the following general rules. Specific requirements for packing are covered in ordnance drawings, specifications, and directives.

The standard container for multiperforated nitrocellulose powders with web thickness of 0.019 inch and above is an all steel box of 110-pound capacity, constructed in accordance with ordnance drawings.

Standard containers for most double base powders, single perforated powders, and all powders with web thickness less than 0.019 inch are metal-lined wooden boxes, constructed in accordance with ordnance drawings.

For temporary storage, or transportation to loading plants, most powders may be packed in fiber containers in accordance with instructions issued by the Chief of Ordnance.

In addition to the marking required by Interstate Commerce Commission regulations, the following data should appear on smokeless powder containers: initials of the manufacturer whose formula is used; type of powder; manufacturer's initials; lot number; year of manufacture; caliber of gun for which intended; net weight.

Storage. The methods of piling bulk smokeless powder in boxes are shown on ordnance drawings. These drawings will be followed *when new stock is piled, or existing stock rearranged.*

Smokeless powder containers (bulk) are piled in double ranks, tops toward the aisles, and inclined at a 20-degree upward angle. This angle is to allow for insertion of methyl violet paper in container of powder undergoing inspection, without spilling of powder from the containers. Powder not as yet requiring inspection need not be stored at this angle. When restoring bulk powder containers which require inspection, a point should be made of keeping the methyl violet paper inserts uppermost.

The stability and useful life of smokeless powder are adversely affected if it is stored in a damp atmosphere or subjected to high temperatures. A *combination of the two is particularly bad.* Magazines for smokeless powder should be dry, and the ground around

them should be well drained. They should have a minimum variation in temperature and a free circulation of cool, dry air, except that a free circulation of air is not ordinarily required for smokeless powder stored in igloo magazines. Small-arms powders in bulk are stored in the same manner as cannon powders. As they may deteriorate more rapidly than cannon powders, the selection of proper storage magazines and the maintenance of good storage conditions are most important.

Smokeless powder in containers will not be exposed to the direct rays of the sun for any long period of time. Containers which cannot be placed promptly under cover will be covered with a tarpaulin placed so that air can circulate through the pile.

Rough handling of smokeless powder containers is prohibited, as seams may be opened in the containers or liners thus allowing air and moisture to enter the container, creating conditions which may seriously affect the life of the powder.

Surveillance. All bulk smokeless powder, except those lots manufactured within 15 years of date of inspection, will be inspected in accordance with the following procedure (see also, OFSB 3-13).

Each box will be opened. If the powder smells of nitrous fumes, or if the N/10 methyl violet paper has turned white, that box will immediately be segregated and subsequently be disposed of in accordance with regulations in OFSB 3-13. If neither of the above defects are found, a new dated N/10 methyl violet paper will be placed in the box, and the box returned to storage. If the amount of defective powder in any one lot equals 10 percent of the lot, the balance of the lot will be inspected thereafter at 6-month intervals.

Separate-loading propelling charges follow the same scheme except that inspection is not started until the powder has reached an age of 20 years from date of manufacture. Also the bags shall be removed from the cartridge-storage case for charges for 155-mm gun, 6-inch gun, 8-inch gun, 10-inch gun; 155-mm and 240-mm howitzers; and 12-inch mortars, and inspected for brown spots, odor of nitrous fumes, and general deterioration of the bag.

With charges for 12-inch, 14-inch, and 16-inch guns, the bags will not be removed unless the N/10 methyl violet paper shows signs of discoloration.

Segregated charges will be disposed of in accordance with regulations in OFSB 3-13. Satisfactory charges will be returned to storage with a new dated methyl violet insert.

Where the number of defective charges in any one lot reaches 10 percent, the balance of the lot will thereafter be inspected at 6-month intervals.

Maintenance. *The principal maintenance activities are the repair* of damaged containers and the replacement of defective covers and gaskets. Containers for bulk powder are not ordinarily air-tested in storage. They are substantially made and should not develop leaks after they have been filled and air-tested, unless they have been subjected to extremely rough handling.

Powder will not be stored or shipped in damaged containers. The outer or wood container usually can be repaired or replaced without removing the contents of the inner container. This work will be done in a suitable room or building, free from all other explosives or ammunition, or in clear weather, in the open, shaded from the sunlight at sufficient distance to comply with quantity-distance requirements, but in no case closer than 100 feet from any building containing explosives or ammunition. Safety tools will be used.

When the inner metal container is damaged, or when powder is to be repacked in new or serviceable containers, all repacking will be done in a suitable room or building, free from all other explosives or ammunition, where the powder will not be exposed to a damp atmosphere or the direct rays of the sun. Each container, in which powder is to be repacked, will be air-tested both before and after it is filled. This will be done with the air-testing apparatus used for testing the containers for separate-loading propelling charges, and using a special cover fitted with an air-test hole. The amount of powder at or near repacking operations will be limited to that in one open container and nine closed containers. The distance from nearby buildings containing explosives will be in accordance with the intraplant quantity-distance table, and in no case less than 100 feet. The inner metal container will not be repaired or soldered until precautions have been taken to insure that it contains no loose grains of powder or powder dust. Safety tools only will be used.

Fires. Careful study of the reports of several smokeless powder fires, which have occurred at ordnance establishments, shows that bulk powder in storage constitutes an unusual and severe fire hazard which in most cases can be confined to the building in which it originates. If a fire is discovered in a magazine, there is little chance that the building can be saved, and the efforts of the fire-fighting forces will be confined to protecting adjacent magazines. Because of the intense heat generated by burning smokeless powder, all fire-fighting equipment must be halted at least 200 yards from the fire, and all available cover utilized by the fire-fighting forces. A careful watch will be maintained for burning embers and grass fires in order to prevent the fire from spreading. If a fire occurs in a magazine or repacking room where employees are working, and involves only a small amount of loose powder (not more than 150 pounds), an effort should be made to control and prevent the spread of the fire.

NOTE: All types of smokeless powders, are class 2, except for the extremely fine flake powder of high nitroglycerine content used in

trench mortar ignition cartridges, which are class 9. In the case of the latter type, the powder will be stored as class 9 explosives as regards quantity-distance tables. Personnel engaged in combating fires involving this type powder will use the same precautions as for bulk high explosives.

EXPLOSION HAZARDS OF SMOKELESS POWDER.

When smokeless powder, other than the extremely fine flake powder, in bulk, of high nitroglycerine content as used in trench mortar ignition cartridges, is stored in magazines in containers or propelling charges, there is no evidence to indicate that fires will rise to any unusual hazards. Cases have been reported in which pressures sufficiently great to result in structural damage have occurred but which involved the burning or explosion of smokeless powder under circumstances not ordinarily encountered in the storage of the material in standard containers. It is known that pressures may develop when extremely fine bulk flake powder of high nitroglycerine content is burned under normal storage conditions; for this reason, powders of this type are considered class 9 explosives and are to be stored and handled as such. Normally, when other types of smokeless powders are burned under conditions encountered in storage, dangerous pressures do not develop. There is, however, evidence that explosions of nitrocellulose powders up to large grain sizes are capable of being propagated from box to box when initiated by the detonation of a high-explosive charge.

Safety Precautions. Smokeless powder exposed to extremely adverse conditions of moisture and temperature for a long period of time may ignite spontaneously. Care will be taken to protect powder from excessive temperature and moisture, as such conditions hasten decomposition. It always must be protected from the direct rays of the sun. If powder becomes wet or damp, or if there is any reason to suspect that it has been exposed to moisture, it will be segregated from other powder until it has been found satisfactory by stability tests. When leaking containers are discovered, an examination of the contents will be made for the odor of decomposing powder and the evolution of reddish fumes. If any such condition is observed, the powder will be segregated or disposed of in accordance with pertinent Ordnance Field Service Bulletins.

Powder will always be stored in containers, but should powder be spilled or powder dust accumulate, it will be removed immediately, as loose powder and powder dust are dangerous fire hazards. Dragging powder boxes over smokeless powder grains has been the cause of serious fires. Extreme care will be taken to guard against powder dropping into cracks and crevices or lodging in places where it may remain over a long period of time without being detected. It is believed that many fires have occurred from this cause.

In opening containers or repairing damaged boxes containing smokeless powder, safety tools will be used, and if powder is being repacked, the floor will be covered with tarpaulins, and safety shoes will be worn.

COMPOUND PROPELLANTS.

Ballistite. A double base compound propellant is a powder composed of nitrocellulose and nitroglycerine.

A single base compound propellant is a powder composed of nitrocellulose and other explosive factors.

Ballistite is our best example of a double-base powder. It is composed of: 60 percent nitrocellulose; 39 percent nitroglycerine; 0.75 percent diphenylamine; coating graphite.

It may be found in use as a propellant for trench-mortar ammunition and as a propellant for shotgun shells.

It is of satisfactory stability, the oily nitroglycerine content overcoming hygroscopic tendencies of the nitrocellulose.

E. C. Blank Powder. E. C. Blank powder is our best known single-based compound powder. It is composed of: 80.4 percent, nitrocellulose; 8.0 percent potassium nitrate; 8.0 percent barium nitrate; 3.0 percent starch; 0.6 percent diphenylamine.

It is used as a bursting charge for fragmentation hand grenades and as a filler for small-arms blank ammunition.

Storage. Compound propellants require similar precautions in storage and handling to those discussed for smokeless powder earlier in this chapter. They are not identical, however, and further study should be made before extensive handling of these powders.

FURTHER REFERENCES:

TM 9-2900; O.O. 7224, Ordnance Safety Manual.

Chapter 3
High Explosives

GENERAL.

When the entire field of high explosives is considered, the term "military high explosives" has a restricted application to a small number of substances. Those substances whose rate of decomposition is so rapid as to preclude their use as propellants, but which on the other hand bring about a very disruptive action are known as detonating substances, or more commonly as high explosives. The selec-

tion of various substances for use as a military high explosive are dependent on various factors.

Requirements for a Military High Explosive. The following factors must be considered in the selection of a substance for military use as a high explosive:

1. Availability of raw material. There are many high explosives which are excellent for use, but cannot be used for military purposes because the materials for their manufacture are not available in this country or from friendly neighbors. It is needless to mention that high explosives whose basic materials are available only in enemy territory are unsuitable for use as a military high explosive.

2. Cost of manufacture. Another factor to consider is the cost of manufacturing processes. The basic material may be available, but the machinery, the technical skill required in manufacture, and the danger involved may be so restrictive as to make the cost of its manufacture too expensive. An important point to note is the quantity of explosive desired for military use. That explosive which is used in great quantity must cost less than the explosive used in smaller quantities. For example, the TNT which is used in the greatest quantity as a military high explosive costs $0.14 to $0.25 a pound; tetryl which is used in smaller quantities as a military high explosive costs $0.60 to $1.00 a pound while mercury fulminate which is used in the least amount as a military high explosive costs $3.25 a pound.

3. Stability in storage. Military high explosives must not undergo decomposition in storage. Military high explosives manufactured today may be used years later, and therefore must be stored. High explosives which would deteriorate and be subject to change over a period of time not only under favorable conditions, but even under adverse conditions of storage, such as high temperature and humidity are not desirable for military use.

4. Hygroscopicity. A substance is defined as hygroscopic when it shows a tendency to absorb moisture. Such a characteristic, evidenced in a high explosive, indicates the possibility of this explosive to deteriorate in storage, or to corrode the casing in which it is inclosed.

5. Reaction with metals. High explosives for military use are usually loaded in metal shells, projectiles, and casings. A high explosive which reacts with metals will not only corrode its container, but in many instances will produce new, very sensitive explosive compounds; picric acid, for example, produces metallic picrates. These new compounds or high-explosive salts which are produced are much too dangerous to handle for military use.

6. Sensitivity to shock incident to loading, handling, and shipping. A high explosive used for military purposes must be loaded into the shell, handled, and shipped in large quantities. Many times it undergoes rough treatment during this procedure, treatment which will occur even with reasonable care in handling the explosive. A high explosive which will detonate under shocks which are unavoidable in its transit from the coarse high explosive to the firing point is decidedly not suitable for military purposes.

7. *Sensitivity to setback action in the weapon.* The force of setback that takes place in the barrel of the weapon illustrates a basic principal of physics. From Newton's law, it is known that objects at rest tend to stay at rest and that objects in motion tend to stay in motion. Setback is the force due to this fundamental principal of inertia. The shell with high-explosive filler and all its components are at rest when the shell is placed into the weapon. Suddenly the shell is propelled forward at a very high velocity. All components in that shell tend to fall back toward the base of the shell, and do so with terrific impact. Many high explosives under such conditions may explode. A high explosive for military use which is reasonably well loaded must not detonate in a weapon under such conditions.

8. *Brisance or shattering effect.* A very obvious requirement for a military high explosive is its ability to shatter its surrounding medium when properly initiated. A substance must have brisance or shattering effect to be considered suitable for a military high explosive.

9. *Suitability for its purpose.* Not all high explosives have the same brisance nor the same ability to be initiated by various external forces. A military high explosive on the basis of its characteristics is assigned to a certain use or purpose which is determined mainly by its brisance and sensitivity. It must be suitable for the requirements set forth for that purpose to be considered as suitable for military use. A further study of this point will be made in the chapter dealing with explosive trains.

It must be kept in mind that not all high explosives employed today for military use fulfil all the requirements desired, but several of the requirements are absolutely essential. Therefore, some disadvantages may be overcome in such a way that the military high explosive will meet the requirements deemed necessary for its use. For example, picric acid reacts with metals. This disadvantage can be overcome by painting the inside of the shell with a nonmetallic and acidproof paint. The requirements as listed, therefore, can be considered as those which depict the ideal military high explosive.

TRINITROTOLUENE (TNT).

General. Although trinitrotoluene was known as early as 1863, it was not suggested as an explosive until about 1890, and its importance from a military standpoint dates from 1904. Since that time, it has appeared as the principal constituent of many explosives, and has been used by itself under such various names as triton, trotyl,

tolite, trilite, trinol, tritolo, etc. It is commonly known in this country by the abbreviation TNT. The term trinitrotoluol, which is more generally used than trinitrotoluene, is less correct from the chemical point of view than the latter.

The importance of this explosive is based upon its relative safety in manufacture, loading, transportation, and storage, on the fact that it is not hygroscopic, on the lack of any tendency to form unstable compounds with metals, and upon its powerful, brisant, explosive properties.

Properties. *Color and solubility.* TNT usually resembles in appearance, light brown sugar, although in different grades of refinement or purity its color and appearance vary. When pure, it is a crystalline powder of very pale straw color. It dissolves readily in ether, acetone, alcohol, and various other solvents, but it is practically insoluble in water.

Classification. TNT is classified in U. S. Army Specifications into two grades designated as grade I, with a setting point of 80.2 C minimum, and grade II, with a setting point of 76.0 C minimum. Grade II is obtained directly by the nitrating process, while grade I must be prepared by recrystallization or by special chemical treatment of grade II material.

Safety precaution. Both grades of TNT are slightly toxic, and it is necessary that proper precaution be taken by those engaged in its manufacture or handling to avoid inhaling the vapors or dust from the molten or crystalline material. Good ventilation in manufacturing or shell loading plants is highly essential, and personal cleanliness should be enforced. All clothing should be changed upon the beginning and completion of work.

Stability. TNT is one of the most stable of high explosives, and when properly purified may be stored over long periods of time without alteration. It is quite insensitive to blows or friction, but can be detonated by severe impact between metal surfaces. When ignited by flame, it burns rapidly without explosion. Burning or rapid heating of large quantities especially in closed vessels may, however, cause violent detonation. It should therefore be melted in equipment so arranged that the maximum temperature of the melting unit cannot exceed 105 C.

Chemical action. While TNT has no tendency to form compounds with metals, thereby producing sensitive salts, it will react with alkalies such as sodium hydroxide or sodium carbonate to form unstable sodium salts which are quite sensitive. For this reason, the use of alkalies in purification of TNT is not permissible.

Detonation. TNT in crystalline form detonates readily under the influence of a No. 6 detonator (containing 1 gram of mercury fulminate). When compressed to a high density, it requires a No. 8

detonator (containing 2 grams of mercury fulminate), and when cast, it is necessary to employ a booster charge of pressed tetryl, or an explosive of similar high brisance, to insure complete detonation.

TNT may be classed as a "quick acting" explosive. It detonates at a rate varying from about 5,200 meters per second for loosely compressed material to nearly 7,000 meters per second for material cast or compressed to its maximum density.

Decomposition. The decomposition of TNT on explosion may be regarded as occurring according to one or both of the following reactions:

$$2C_6H_2(CH_3)\ (NO_2)_3 = 12\ CO + 2CH_4 + H_2 + 3N_2$$

or

$$2C_6H_2(CH_3)\ (NO_2)_3 = 12\ CO + 5H_2 + 3N_2 + 2C.$$

The deficiency in oxygen as indicated by both of these reactions is always apparent from the black smoke produced by the explosion of TNT. This deficiency of oxygen may be compensated for by addition of such substances as ammonium nitrate or sodium nitrate in various proportions, the resulting mixtures being designated as amatol and sodatol, respectively.

Manufacture. Manufacture of TNT involves the following processes:

1. Nitration of: toluene to mononitrotoluene; mononitrotoluene to dinitrotoluene; dinitrotoluene to trinitrotoluene.

2. Washing the finished product until free of acid.

3. Purification by remelting and chemical treatment or recrystallization.

4. Granulation, screening, and drying.

The detailed procedure involved in each of these steps will not be discussed here. It may be found in TM 9-2900, and other references indicated at the close of this chapter.

Uses. *Bursting charge.* Grade I TNT is slightly more expensive than grade II because it requires the additional purification. Grade I is used as the bursting charge for high-explosive shell, either alone or mixed with an equal weight of ammonium nitrate to form 50/50 amatol. (The TNT, in either case, being melted so that the shell is filled by a casting or pouring process.) Grade II is used only in 80/20 amatol, where it is mixed in the molten state with four times its weight of ammonium nitrate and filled into high-explosive shell by hand stemming or by means of a screw filling machine.

A charge of about 1¼ pounds of cast TNT in a 75-mm high-explosive shell weighing about 10 pounds breaks up the shell into approximately 400 fragments retained on a 4-mesh screen.

Other military uses for TNT are as a bursting charge for rifle grenades, airplane drop bombs, naval submarine mines, depth bombs, and as a constituent of propellent powder. In airplane bombs, it has

the disadvantage that penetration of the bomb by a rifle bullet may cause an explosion of the charge. This is also true of amatol, which is used extensively in drop bombs.

Demolitions. TNT is also used for military purposes in demolition work on bridges, railroads, etc., and for land mines placed under enemy trenches or fortifications. For demolition work carried on by the Corps of Engineers, the TNT is made up in the form of small, highly compressed blocks inclosed in a fiber container which protects them from crumbling in handling and renders them waterproof.

Airtight seal. TNT is used in conjunction with other explosives, such as amatol, to seal the amatol from moisture and to act as an efficient explosive to receive the detonating wave from the booster.

Blasting work. TNT has been demonstrated to be suitable for all kinds of blasting work where 40 or 60 percent dynamite is used and to give practically equal effects. It is well adapted for "adobe" shooting or "mud capping," terms applied to breaking up large rocks or boulders by means of a charge of high explosive placed on the rock and confined only by means of a shovelful of mud or wet earth thrown over it. Only quick-acting explosives can be successfully used for such work. Even in drill holes containing water, TNT gives excellent results because of the fact that it is insoluble in water. However, its use for blasting has been negligible because of the fact that it is expensive as compared with commercial dynamites.

Detonating fuse. "Cordeau Bickford," a trade designation for detonating fuse, consists of a flexible lead tube, smaller in diameter than a lead pencil, filled with TNT. It is quite extensively used in certain blasting operations, especially for insuring complete detonation of large charges of dynamite. The detonating fuse, being passed through the entire length of the charge and detonated at its external end by means of an ordinary blasting cap, transmits its high rate of detonation to the entire charge of dynamite.

AMMONIUM PICRATE (EXPLOSIVE D).

General. The use of ammonium picrate as an explosive was patented by Nobel in 1888 (Mosenthal, Jour. Soc. Chem. Ind., Vol. 18, p. 447, May, 1899), although even prior to that time Brugere made use of a mixture of ammonium picrate and sodium nitrate as a propellent explosive.

The importance of ammonium picrate as a military explosive is due entirely to its marked insensitiveness to shock and friction, which makes it well suited for use as a bursting charge in armor-piercing projectiles. From the standpoint of brisance, however, this explosive is inferior to TNT.

Properties.

Color and solubility. Ammonium picrate is soluble in water, crystallizing from its solution in orange-yellow needles darker in color than picric acid. It resembles picric acid in its bitter taste and property of dyeing the skin, clothing, etc., of those engaged in its manufacture or handling.

Hygroscopicity. It has a much greater tendency to absorb moisture than has picric acid, samples having been found to absorb over 5 percent by weight of water during storage for 1 month in an atmosphere saturated with moisture.

Chemical action. Like picric acid, ammonium picrate can react with metals to form metallic picrates, but it reacts with much less readiness than picric acid; in fact, when dry its action is almost negligible. Wet ammonium picrate reacts slowly, especially with copper or lead, to form picrates which are particularly sensitive and dangerous.

Heat action. Ammonium picrate does not melt on heating, but explodes when heated to a temperature of about 300 C. Small traces of metallic picrates may however lower this ignition temperature appreciably.

Sensitivity. Ammonium picrate is the least sensitive of all military explosives used as the bursting charge for shell. Its insensitiveness to shock accounts for it being given preference over TNT or amatol as the bursting charge for armor-piercing, base-fuzed shell. It is also more insensitive to detonation by means of mercury fulminate than is TNT. At a pressure of about 12,000 pounds per square inch the two explosives have the same densities, about 1.48.

Toxicity. Like TNT and picric acid, ammonium picrate liberates free carbon on explosion, giving a black smoke. The products of explosion, although more disagreeable in odor, are less poisonous than those from TNT and picric acid in that they contain less carbon monoxide.

Manufacture.

Process. The manufacture of ammonium picrate consists in the main of a simple neutralization of picric acid by means of ammonia either alone or in combination with ammonium carbonate. This process is not attended with any serious manufacturing difficulties or dangers, provided one excludes the possibility of leaking ammonia pipes.

Detailed presentation of the manufacturing methods may be found in references listed at the close of this chapter.

Use. As has been mentioned, ammonium picrate is used as the bursting charge for armor-piercing shell on account of its insensitiveness to shock which permits the shell to pass through the armor without exploding. Owing to the fact that it cannot be melted without decomposing, it must be loaded into the shell by pressing. The interior of the shell is covered with a suitable nonmetallic paint or

varnish. It has no commercial use as an explosive, although it enters into the composition of numerous patented blasting explosives which have not been used to any great extent.

Storage.

Regulations. Storage of ammonium picrate is governed by the same regulations as are applicable for the storage of TNT both as to type of magazine and rules for handling, and special regulations governing this particular explosive are not necessary.

Special precautions. Ammonium picrate which has been pressed at a shell-loading plant and removed from a shell is very much more sensitive to shock or blow than new material, and there are cases on record where serious accidents have happened in the loading of shell with ammonium picrate so treated. If it becomes necessary to store this material, special precautions should be observed to protect it against shock or fire, and it preferably should be stored in a building by itself.

Although less sensitive than TNT, ammonium picrate can be exploded by severe shock or friction, is highly inflammable, and when heated to a high temperature may detonate. It is therefore necessary that it be treated with proper care as a high explosive.

Magazines. Since it absorbs moisture, it should be stored in dry magazines and protected from dampness. Moisture, however, has no effect on ammonium picrate except to reduce its explosive strength and its sensitiveness to detonation.

Containers. Ammonium picrate is always stored in wooden containers because of the possibility of its forming metallic picrates in contact with metals, especially when moist.

PICRIC ACID.

General. Picric acid or trinitrophenol was first adopted as a military high-explosive by the French Government in 1886 under the name of melinite, and has since been used to a greater or less extent by almost all countries with or without addition of various materials intended to reduce its melting point. The British explosive designated as lyddite and the Japanese explosive schimose are both cast picric acid, and various names are given to other shell explosives the chief component of which is picric acid.

Properties.

Color and solubility. Picric acid is a lemon-yellow, crystalline solid, only slightly soluble in cold water but soluble in alcohol, benzene, and other organic solvents. A very small amount is, however, sufficient to color a large volume of water a distinct yellow color. It likewise stains the skin of workmen, colors clothing, hair, and everything else with which it comes in contact, and has an exceedingly persistent, disagreeable, bitter taste. Its property of coloring is utilized in the dye industry, and in fact, picric acid was long known as a dyestuff before its explosive nature was discovered. It has no tendency to absorb moisture from the air.

Heat action. Picric acid melts at a temperature of about 122 C when pure, and is usually required for explosive use to have a melting (or solidifying) point of at least 120 C.

Chemical action. Being an acid, it has the property of combining with ammonia and alkalies and with many of the metals, forming salts which are called picrates. Some of the picrates are much more sensitive than picric acid itself, and it is therefore necessary that formation of these picrates be avoided by keeping picric acid from direct contact with those metals with which it readily reacts.

Precautions. Picric acid is not as toxic as TNT and the chief danger in connection with its use is probably the fumes given off from the molten explosive in loading shell. While practically no trouble from poisoning results in manufacture or handling of picric acid, care must be taken, however, to avoid breathing the large amounts of picric acid dust that may arise in screening or packing the dry material.

Stability. Picric acid is entirely stable. It has no tendency to decompose at any temperatures which it might meet in storage. On sudden heating at temperatures much above its melting point (122 C) it may explode, although many cases are noted where considerable quantities of picric acid have burned without explosion. Presence of any trace of explosive that will detonate more readily such as metallic picrates may cause sudden detonation of burning picric acid.

Detonation. It has about the same sensitivity to shock or friction as TNT and is somewhat more readily detonated by means of a detonator. Picric acid is one of the most powerful of military explosives. Its high strength or concussive effect is due to its high rate of detonation which, for the cast or highly compressed explosive, is about 7,000 meters per second, slightly greater than that of TNT under the most favorable conditions. By both the Trauzl lead block test and the ballistic pendulum test, picric acid shows appreciably greater strength than TNT, being exceeded only by tetryl and TNA. The results of these methods of testing are confirmed by actual fragmentation tests of high-explosive shell where it is found that a larger number of shell fragments are produced from picric acid than from TNT at equal loading densities.

Use. The fact already noted that picric acid combines readily with some metals to form picrates which are unduly sensitive to friction, shock, or heat has been detrimental to the use of picric acid for military purposes in spite of the fact that it is a stronger explosive

than TNT. When a nonmetallic lining is used for the shell cavity as for instance, certain lacquers, varnishes, or paints, danger of formation of these salts is obviated to a great degree. Introduction of TNT as a military explosive has resulted in gradual abandonment of picric acid by practically every country except France where it was largely used during World War I. In the United States, it is used for conversion into "Explosive D" or ammonium picrate which is used in base-fuzed shell for seacoast cannon. Picric acid has also found use as a booster explosive and even as a substitute for part of the mercury fulminate charge in detonators.

Picric acid has been used extensively in the form of mixtures with other nitro compounds. Such mixtures, having a lower melting point than picric acid, can be melted and cast at temperatures below 100 C. The mixtures are more generally practicable because of the hazard involved in melting picric acid at the relatively high temperature required. Some of the compounds which have been used with picric acid are trinitrotoluene, trinitrocresol, trinitrobenzene, and the dinitro and mononitro derivatives of phenol, cresol, and naphthalene. Little, if any, change in brisance results from the addition of the trinitro compounds, but the addition of the mono and dinitro compounds causes a reduction in brisance in proportion to the amount added.

Storage. Rules governing storage of dry picric acid are the same as for TNT. Dimension of magazines should not exceed 42 by 26 feet. It is necessary that all dust accumulating from dry picric acid should be carefully removed from any point in or around the buildings, conveyors, or cars. Although dust originating from this source is not as dangerous as that from black powder, it is nevertheless a matter of record that serious explosions have been caused from this source. Safety shoes must be worn in every instance where picric acid is being handled.

NITROSTARCH EXPLOSIVES.

General. During World War I, certain explosives having nitrostarch as a base were used under the designations "Trojan grenade explosive," "Trojan trench-mortar shell explosive," and "Grenite." These explosives were frequently referred to as "nitrostarch," but it should be noted that pure nitrostarch was not used alone as a military explosive, the nearest approach to it for military purposes being grenite, which was about 95 percent nitrostarch, the balance being a binding material added for the purpose of granulating. The two Trojan explosives which were practically identical in composition contained approximately 25 percent nitrostarch with ammonium nitrate, sodium nitrate, and small amounts of materials added for the purpose of stabilizing, reducing sensitiveness and hygroscopicity, and neutralizing any possible acidity of other ingredients.

These nitrostarch explosives were used for the reason that at the time the United States entered the war a decided shortage of TNT was indicated and investigation showed nitrostarch explosives to be entirely suitable for trench warfare purposes and to offer the advantages of low cost and ample supply of raw materials, etc.

Properties.

Color and solubility. Nitrostarch is a white, finely divided material similar in appearance to ordinary powdered starch. When observed under the microscope, there is no appreciable difference between nitrated and unnitrated starch until the granules are treated with iodine, which colors the unnitrated starch blue but does not affect the nitrated product. Nitrostarch is insoluble in water and does not gelatinize or form a paste when heated with water, thereby differing from starch. The grade of nitrostarch ordinarily employed contains from 12.50 to 12.75 percent nitrogen; that prescribed for military purposes contains at least 12.80 percent. All nitrostarch is readily soluble in acetone, solubility in ether-alcohol in general increasing as the nitrogen content decreases. It has no great tendency to absorb moisture from the atmosphere beyond the amount of 1 to 2 percent.

Trojan grenade or trench-mortar shell explosive differed greatly in appearance and in certain of its properties from straight nitrostarch, being of grayish-black color and of about the consistency of ordinary brown sugar, having a slightly damp feel and tendency to pack under compression due to the small amount of mineral oil contained as an ingredient. This oil, besides decreasing the sensitiveness of the explosive to ignition and to shock or friction, helped to reduce its attraction for moisture, the mixture of ammonium nitrate and sodium nitrate which it contained being very hygroscopic. In spite of this coating of oil, the Trojan explosive when spread out in a thin layer in a damp atmosphere rapidly absorbed moisture to such extent that it became decidedly wet. Under ordinary working conditions, therefore, great care was taken in loading this explosive to avoid absorption of an undesirable amount of moisture.

Grenite, which was almost entirely pure nitrostarch with addition of a small amount of oil and a binding material, differed greatly in appearance from Trojan explosive, being in the form of small, white, hard granules which flowed freely without sticking together. Since it contained no ammonium nitrate or other hygroscopic materials, Grenite had no particular tendency to absorb moisture even in damp atmospheres.

Sensitivity. Pure dry nitrostarch is more sensitive to impact than TNT but less sensitive than dry guncotton or nitroglycerin. As mentioned above, it is highly inflammable and readily ignited by the slightest spark such as may result from friction, and like black

powder, burns with explosive violence. It is readily detonated by a mercury fulminate detonator.

Trojan explosive and Grenite were both much less sensitive than straight nitrostarch, being required to pass the pendulum friction test of the United States Bureau of Mines and the rifle bullet test when packed in pasteboard containers. In heavy metal containers, these explosives frequently ignited and burned when penetrated by a rifle bullet, and in rare instances exploded under this test. Trojan explosive was especially insensitive to ignition, being rather difficult to ignite with the flame of a match when spread out unconfined. When once ignited, however, especially in any quantity, it burned freely with a light-colored smoke.

Detonation. Nitrostarch explosives were readily detonated by mercury fulminate detonators, a No. 6 detonator containing 1 gram of fulminate composition, producing complete detonation unless the explosive had been rendered unduly insensitive by absorption of excessive moisture or by other cause.

Stability. Early attempts to manufacture nitrostarch resulted in production of material which was unstable, and numerous statements found in literature of explosives refer to nitrostarch as being unsatisfactory for use as an explosive because of sensitivity and instability. However, manufacturers in this country succeeded in placing on the market nitrostarch explosives which proved highly satisfactory in these respects and found considerable application as blasting explosives. Developments led to a product which met requirements prescribed for military explosives. However, the Trojan explosive if allowed to absorb undue quantities of moisture, especially in a warm atmosphere, tended to deteriorate, being quite similar to nitrocellulose in this respect.

Use.

Trojan explosive. The Trojan nitrostarch explosive was used as the bursting charge for hand grenades, rifle grenades, and trench-mortar shell. It was well adapted to such purposes, but was not considered for use as a bursting charge for high-explosive gun shell. Its physical consistency was such that it was loaded into grenades through the small filling hole by means of vibrating machines, the explosive being "jarred" into the grenade through small funnel openings. Trench-mortar shell were loaded by hand-stemming.

Grenite. Grenite was used only for grenades and was considered too sensitive for use as a trench-mortar shell explosive. Being granular and "free-running," it was readily loaded into the grenades through funnel openings, no attempt being made to pack it to a high density.

Nitrostarch. Nitrostarch has been considered for the manufacture of smokeless propellent powder and numerous attempts have been made to develop a satisfactory powder of this type, but the problem cannot as yet be considered solved.

Nitrostarch explosives, similar to Trojan grenade explosive, have been used for a considerable number of years as blasting explosives for use in mining, quarrying, and other engineering operations, and have met with considerable success as substitutes for the more expensive nitroglycerin explosives.

There has recently been adopted, after thorough investigation, a nitrostarch demolition explosive as a substitute for TNT. This explosive is somewhat similar to that used during the World War, but the formula has been modified by raising the nitrostarch content and the replacement of the ammonium nitrate with barium nitrate. It can be consolidated into blocks in the same manner as TNT, and in comparison tests it has been found that the TNT formula for computing small charges are directly applicable to the nitrostarch demolition explosive.

Storage. Storage of nitrostarch explosives, in general, is mainly a fire risk, that is, the danger accompanying storage is more one of fire than of explosion. However, burning may proceed at such a rate as to be almost explosive in nature, and the fact that nitrostarch can be exploded by impact should not be overlooked.

Magazines. Magazines should be kept at as low temperatures as possible in order to avoid as much as possible the tendency of nitrostarch to undergo decomposition on heating. A reasonably dry atmosphere in magazines is also essential for the Trojan explosive. This explosive was not suitable for storage in bulk in wooden containers because of its hygroscopicity. Even when loaded into grenades it tended to absorb moisture. Long contact of the explosive with the metal parts of the grenade, either iron, brass, or copper, resulted in corrosion.

Handling. There is no danger of poisoning of any kind connected with the handling of nitrostarch explosives.

TETRYL.

General. The high explosive commonly known as tetryl is trinitrophenylmethylnitramine. It is a derivative of benzene and is therefore in the same class of aromatic nitro compounds as TNT. Tetryl was first synthesized by Mertens in 1877. It did not acquire prominence as a military explosive until World War I when it was used as a booster explosive.

Properties.

Chemical and physical. Tetryl is a fine crystalline powder of a yellow color, practically insoluble in water but soluble in acetone, benzene, and other solvents. It is readily recrystallized and can therefore be obtained in very pure condition if desired. It melts when pure between 129 C and 130 C. Tetryl is poisonous when

taken internally, and precaution is necessary in its manufacture, especially regarding the dust encountered in handling and packing the dry material. It has a higher nitrogen content (24.4 percent) than any other military explosive. Tetryl is practically nonhygroscopic, absorbing less than 0.1 percent moisture when stored for several days in a saturated atmosphere.

Stability and sensitivity. Tetryl is stable at all temperatures which may be encountered in storage. When heated above its melting point, it undergoes gradual decomposition and explodes when exposed to a temperature of 260 C for 5 seconds. It is more sensitive to shock or friction than TNT, being of about the same order of sensitivity as picric acid. It is slightly more sensitive to detonation by means of mercury fulminate than TNT, and is readily exploded by penetration of a rifle bullet.

Detonation. Tetryl has been found to have a rate of detonation somewhat higher than the maximum rate obtained with TNT (7,000 meters per second). Strength tests such as the Trauzl lead block test show tetryl to be stronger than any other military high explosive, the average expansion produced in the lead block for the more common military high explosives being as follows: tetryl, 320 cubic centimeters; picric acid, 300 cubic centimeters; TNT, 260 cubic centimeters.

Use. *Charges.* The high-explosive strength and brisance of tetryl would seem to adapt it for use as a bursting charge, but its sensitivity to mechanical shock is such that if used as a shell filler it would not withstand shock of discharge of the gun. It is, however, sufficiently insensitive that when compressed into a booster it is perfectly safe. In this condition, it is readily detonated by the detonator in the fuze of the shell, and the violence of its detonation insures a high order of detonation of the bursting charge.

Tetryl has been adopted as a booster explosive. Formerly it was combined with TNT (grade I), the two explosives being usually loaded separately into the booster casing in the form of highly compressed pellets.

Detonator. It is also used in detonators for both military and commercial purposes as a base charge, the tetryl being pressed into the bottom of the detonator shell and then covered with a small priming charge of mercury fulminate, lead azide, or other initiator.

Storage and Handling. The same precautions should be observed in storage and handling of tetryl as in the case of other sensitive high explosives. It should be kept dry because moisture interferes with its effectiveness. It must be properly protected from bullet fire in brick or hollow tile magazines with iron doors and window shutters. Detonators, blasting caps, fuzes, dynamite, etc., must not be stored with tetryl. Rubber soled shoes should be worn in magazines and every precaution taken to prevent ignition or explosion from friction or blows due to rough handling.

MERCURY FULMINATE.

General. Mercury fulminate is one of the explosives used for bringing about detonation of high explosives. It detonates completely and with great violence on ignition by means of a flame such as the spit from a fuze or by means of an electrically heated wire. This fact, together with its property of initiating detonation of other explosives, makes it a most suitable detonator material.

Properties.

Color and solubility. Mercury fulminate is a heavy, crystalline solid, white when pure, but ordinarily of a faint brownish yellow or grayish tint. It has practically no tendency to absorb moisture from the atmosphere. It is only slightly soluble in water, 100 parts of water at 15.5 C (60 F) dissolving less than 0.01 part of fulminate, and may be kept in contact with water for long periods of time without undergoing change.

Size of crystals. Size of the crystals of mercury fulminate is an important factor, since it has been determined that very finely divided fulminate consisting mostly of fragments of crystals and usually containing an excessive amount of impurities is less efficient in detonating value and strength than larger crystals. In specifying the size of crystals desired, however, consideration has been given to the possibilities of controlling this feature in manufacture and also to the fact that there is some reason to believe that very large crystals of fulminate are more sensitive to friction or shock than smaller ones. As indicated below, U. S. Army specifications for mercury fulminate prescribe definite limits for the size of the crystals.

Impurities. Mercury fulminate is required by U. S. Army specifications to be at least 98 percent pure and the amounts of impurities which it may contain are strictly limited. The most objectionable impurities are:

Free metallic mercury, for the reason that it readily attacks copper or brass with which it may be in contact when loaded into fuzes, detonators, or primers, causing the metal to become brittle.

Acidity, which would cause deterioration of the explosive composition and corrosion of metal parts.

Insoluble material such as sand and grit, which might cause explosion of the dry fulminate in loading operations.

If improperly manufactured or incompletely washed, the fulminate may also contain various compounds of mercury which might produce decomposition and would certainly diminish explosive efficiency.

Stability. Mercury fulminate has been kept for long periods both dry and wet, and is believed to undergo practically no change when properly manufactured and stored. However, when stored either wet or dry at tropical temperature gradual deterioration takes place. It has been found that when stored at 35 C (95 F), mercury fulminate deteriorated to the point of malfunctioning in about 3 years and at 50 C (122 F) it deteriorated to practically the same degree in 10 months. It is never stored in quantity in dry condition except when loaded into detonators, fuzes, or primers for the reason that when dry it is readily detonated by friction or shock. Whereas, the great majority of high explosives will burn without detonating when ignited by a flame especially if a relatively small amount of the explosive is ignited, mercury fulminate is one of the so-called "primary" or "initiating" explosives which detonate completely on being heated to their ignition point by means of a flame or hot wire.

The presence of even small amounts of moisture in mercury fulminate greatly reduces its efficiency, and as little as 1 percent is said to cause failure to detonate. However, fulminate completely saturated with water may be detonated by detonation of dry fulminate in contact with it.

Sensitivity. By usual methods of determining ignition temperature, mercury fulminate detonates at a temperature of about 180 C (about 356 F), but under varying conditions detonation may result at much lower temperatures. Sensitivity to shock is much greater at elevated temperatures than under storage conditions.

When loaded into commercial detonators, mercury fulminate is usually compressed at pressures of about 3,000 pounds per square inch. In this condition, its explosive properties are not appreciably different from those of loosely compressed material. At greater densities obtained by higher pressures, there is a gradual reduction in sensitivity, until at such extreme pressures as 25,000 to 30,000 pounds per square inch fulminate entirely loses its property of detonating when ignited and will only burn. In this condition, it is referred to as "dead pressed." If, however, such highly pressed fulminate is initiated by loose fulminate or other initial detonating agent, it will detonate at even higher rates than are obtainable at low densities.

Although fulminate can be pressed under very high pressures without explosion, the presence of any particles of sand or grit is very dangerous in any pressing operation. Presses for loading are always carefully protected by heavy barricades, and no one is permitted to be near the press during operation.

The readiness with which dry mercury fulminate detonates from the effect of blows or friction is the chief reason for the fact that its transportation and storage in the dry state is not permitted. Tests with a special type of impact machine showed that mercury fulminate detonated from the blow of the falling weight dropped from a height of only 2 centimeters (about 0.8 inch), while TNT in the same apparatus required a drop of about 120 centimers (48 inches).

Detonation. For a number of years, mercury fulminate was considered to have special properties which made it an especially favorable initiating agent and numerous theories were advanced to account for its so-called "unique" properties. As a matter of fact, mercury fulminate has been used only because of its extreme sensitivity to flame or impact. In all other respects, mercury fulminate is inferior to other high-explosives such as TNT, tetryl, and picric acid as a detonating agent. For example, mercury fulminate has a rate of detonation of about 4,000 meters per second as compared with 6,800 meters per second for TNT under the same conditions. In the Trauzl lead block test, mercury fulminate produces an expansion of 213 cubic centimeters and TNT 260 cubic centimeters. The trend in military and commercial detonators for the past several years has been gradual replacement of the major portion of the fulminate charge with some high explosive to increase efficiency of the detonator, the fulminate being used only as a cover charge to initiate detonation of the high explosive forming the base charge in the detonator.

Use. Mercury fulminate is used only for the purpose of bringing about the detonation of other high explosives or the ignition of propellent explosives. In detonators for commercial or military use it may be used alone or mixed with from 10 to 20 percent of potassium chlorate. The usual grades of detonators contain from 15 to 30 grains of fulminate or its equivalent.

The ignition of propellent explosives, for example, smokeless or black powder in small arms cartridges, is effected by the flame from a primer or cap, the charge of which is usually a composition containing mercury fulminate mixed with other flame-producing materials such as potassium chlorate and antimony sulfide. The primer is initiated by impact of the firing pin.

Storage. Mercury fulminate is always stored thoroughly saturated with water.

When left in the barrels during storage, regular inspection must be made to insure that the barrels are kept always full of water and are not leaking.

Fulminate must not be stored with any other explosives for the reason that explosion of even a relatively small amount of dry fulminate may cause detonation of the wet material, effect of which might be to detonate any other high explosives stored in the same building.

In case of breakage, or other cause by which wet fulminate may be spilled on the floor, it must not be allowed to dry out before cleaning up. Dry fulminate is very sensitive to friction and must be

handled with extreme care. Spilled fulminate may be destroyed by washing floors, benches, etc., with a saturated solution of sodium thiosulfate (photographer's "hypo").

AMATOL.

General. Amatol is a mixture of ammonium nitrate and TNT. Due to the shortage of toluene during the early stages of World War I, the British Government developed this explosive and adopted it after exhaustive tests as a bursting charge for high-explosive shell. The United States Government shortly after its entrance into World War I and for similar reasons authorized its use as follows: 50/50 for shell from 75-mm up to and including 4.7 inches; 80/20 for shell from 4.7 inches up to and including 9.2 inches. The ingredients are mixed by weight. The first figure refers to ammonium nitrate, the second to TNT.

Properties. Amatol is hygroscopic, insensitive to friction, but can be detonated by severe impact. It has no tendency to form dangerous compounds with metals other than copper. It is more insensitive to explosion by initiators than TNT. 50/50 amatol has approximately the same rate of detonation and strength as TNT, but 80/20 amatol is slightly lower in rate of detonation and brisance. On detonation the ammonium nitrate oxidizes the excess carbon of the TNT with the result that 80/20 amatol produces a white smoke on detonation and 50/50 amatol produces a black smoke which is not as dark as that produced by straight TNT.

Manufacture. *50/50 amatol.*

Ammonium nitrate as received may contain some moisture and must be dried to a moisture content of not more than 0.25 percent. Caking may have occurred in barrels or drums in which it was shipped. To break up the lumps, it is often necessary to first run the material through a crusher, after which it is dried to the proper moisture content. After drying, the material is screened to remove any foreign material with which it may have become contaminated. It is now ready for addition to molten TNT. The speed of adding ammonium nitrate to TNT can be increased greatly if the ammonium nitrate can be added while it is still hot. It must be added at a rate so that no solidification of the molten TNT takes place in the melting kettle. Proportions for use in mixing 50/50 amatol range from 45 percent to 55 percent ammonium nitrate. This variation is permitted to take care of the various granulations, fine material requiring more TNT than coarse material. Temperature of the mixture when it is ready for pouring into the shell is 80 C to 85 C.

80/20 amatol. 80/20 amatol is a plastic mass resembling wet brown sugar and cannot be loaded by the casting method. The principal difficulty experienced with 80/20 amatol is to obtain ammonium nitrate which has proper granulation. With very fine material, plasticity of the mass is such that when loaded the density falls below the point desired, namely, not less than 1.38. With coarse material molten TNT is not completely absorbed, and a relatively large amount leaks out in the extruding operation which results in a charge of low density. It is, therefore, essential that granulation be such as to give a mixture which will not permit leaking of TNT and which will be sufficiently plastic to consolidate well from the extruder. It has been found that a mixture of coarse and fine material is the most suitable for this operation. Granulation requirements are through a No. 10 U. S. standard sieve not less than 99.0 percent; through a No. 10 on No. 35, 32 to 48 percent; through a No. 100, 15 to 30 percent.

Preparation of 80/20 amatol is conducted in a mixing kettle having a capacity of about 500 pounds of amatol. The correct amount of ammonium nitrate is added to the kettle and heated to the point where solidification of TNT will not occur. When the ammonium nitrate has been raised to at least 90 C, molten TNT is added, and the charge thoroughly mixed for 15 minutes. At the end of this time, it is transferred to the extruding machine from which it is forced into the shell by means of a screw working inside of a steel tube. This machine is counterweighted so that the material is forced into the shell under a definite pressure.

LEAD AZIDE.

General. Lead azide was first prepared and identified by Curtius in 1891, and in 1893 Will and Lenze began an investigation of lead azide as a military explosive. About 1910, commercial manufacture of lead azide was started abroad and has continued up to the present time. Since 1931 it has been produced commercially in this country. This commercial lead azide is free from needle crystals having a maximum dimension greater than 0.1 mm.

Properties. Lead azide (PbN_6) is an initiating compound used for bringing about detonation of high explosives. It is sensitive to flame but is too insensitive to be used alone where initiation is by impact of a firing pin. Lead azide is practically insoluble in water and its hygroscopicity at 30 C and 90 percent relative humidity is only 0.03 percent. It is not easily decomposed by heat as shown by surveillance tests where it has been stored for 15 months at 80 C without any noted impairment in sensitivity or brisance.

Storage. Lead azide is always stored thoroughly saturated with water. It is stored and handled in the same manner as mercury fulminate. Spilled lead azide may be destroyed by washing floors, benches, etc., with a solution of ammonium acetate.

PENTAERYTHRITE TETRANITRATE (PETN).

General. Pentaerythrite tetranitrate, commonly known as PETN, is derived from the nitration of pentaerythritol. PETN is considered by the Interstate Commerce Commission as an initiating agent. It must be packed wet with not less than 40 percent by weight of water in metal barrels, or wooden kegs, in which the material is packed in cloth or rubber bags.

Sensitivity. PETN is more sensitive than tetryl, but not as sensitive as mercury fulminate.

Uses. PETN is used in detonating cord, commercially known as Primacord. Primacord is a flexible, waterproof fabric tube $^{13}/_{64}$ inch (0.203 inch) in diameter with an explosive core of PETN; which has the velocity of detonation of about 20,300 feet per second. In this form, PETN is quite insensitive to shock, flame, or friction, and requires a cap to detonate it. It is now issued in 100-foot spools, is greenish yellow in color, and has a relatively rough waxy surface. These characteristics are not definitely dependable, however, for positive identification of present or future issues.

The extreme violence of a primacord explosion is sufficient to detonate high explosives in intimate contact with it. Hence, it is valuable for safe priming of charges in drill holes and for the simultaneous firing of a number of charges at some distance apart.

PETN has a second use in that it is used in conjunction with TNT to form pentolite, a bursting charge for certain types of ammunition.

TRIMONITE.

Trimonite, like amatol is specified as a substitute explosive for shell and bomb loading.

It is composed of 88 percent picric acid and 12 percent alphamononitronaphthalene. The reason for using 12 percent alphamononitronaphthalene is to obtain a mixture which can be melted in melting kettles using not more than 10-pound steam pressure. Picric acid melts at 120 C which prohibits its use as a casting explosive if low-pressure steam equipment is the only type available. However, by mixing 12 percent alphamononitronaphthalene with picric acid, the material becomes fluid at about 100 C and can be cast without any trouble.

Trimonite resembles 50/50 amatol in all its characteristics, with the single exception that it is likely to form sensitive compounds with metals. Provision must be made, therefore, that it will not come in contact with metal, such as zinc or lead. It has one advantage over TNT in that there is no danger of exudation.

In all tests conducted to date, no results have been obtained which would prohibit its use, and in case of an emergency it could be loaded with equipment available for the loading of TNT or 50/50 amatol.

TRIDITE.

Tridite consists of approximately 90 percent picric acid and 10 percent dinitrophenol. It was formerly specified as a substitute explosive for shell and bomb loading, but has been replaced as a substitute by trimonite. It has similar advantages to those of trimonite, and adaptability of these two explosives is almost identical, however, is more dangerous to load because of the toxicity of its fumes which accompany its melting.

TETRYTOL.

Tetrytol is a mixture of tetryl and molten TNT. As some of the tetryl goes into the solution, the mixture can be successfully cast with as high as 70 percent tetryl and 30 percent TNT by weight. The principal use and advantage of tetrytol is in loading boosters and bursters by the cast method. These items were previously loaded with dry tetryl which was pressed into pellets and then reconsolidated by pressing into the burster or booster casing. The mixture is agitated until ready for casting to prevent separation or precipitation. The use of tetrytol loaded into boosters and bursters has been approved except where the loaded item is plunged into or surrounded by a hot bursting charge, such as in the case of auxiliary boosters in general purpose bombs, where a remelt of the tetrytol might occur. The advantages of casting over the pellet reconsolidation, especially in long burster tubes, is tremendous from a standpoint of simplicity of operations, safety, and cost of equipment.

PENTOLITE.

Pentolite is a mixture of PETN and TNT. The 50/50 mixture results in a considerable increase in the brisance of TNT as measured by the rate of detonation. It is more sensitive to shock and friction than TNT, and where booster cavities have to be drilled, a mixture of 10 percent PETN and 90 percent TNT is used for the booster surround.

50/50 pentolite in the dry state is packed in the same manner as TNT. It is loaded by the casting method, 5 pounds of steam pressure on a steam jacketed open kettle being sufficient to melt the dry material. As the dry material melts, it must be constantly agitated to keep the PETN in suspension, as only a small portion of it goes into solution with the TNT. This agitation, usually by air-driven propellers or hand paddles, must be continued until the material is cast into the ammunition being loaded.

The stability of pentolite is not as favorable as that of straight TNT. Long periods of storage under high temperature may result in a separation of the material and the loss of its greatest effectiveness

as an explosive of high brisance. Every effort must be made to store it in a cool, dry place.

GENERAL SAFETY PRECAUTIONS PERTINENT TO HIGH EXPLOSIVES.

Safety shoes will be worn in repacking rooms or buildings, and whenever loose high explosives are handled. The wearing of safety shoes by personnel handling high explosives in boxes or other containers is at the discretion of the commanding officer, who should be guided in his decision by existing conditions. Boxes containing high explosives will be opened and repaired with safety tools. Containers will not be opened in a magazine in which explosives or ammunition are stored.

TABLE OF USES AND LOADING METHODS OF HIGH EXPLOSIVES

Explosive	Main Use	Method of Loading, If Any
TNT	Bursting charge	Casting or pouring
Amatol 50/50	Bursting charge	Casting or pouring
Amatol 80/20	Bursting charge	Extrusion
Picric Acid	Basis for making other explosives	
Explosive D	Bursting charge for A.P. shells	Tamped in increments
Trimonite	Bursting charge	Cast
Tridite	Bursting charge	Cast
Nitrostarch	Demolition work	Pressed
Tetryl	Booster	Pressed in pellets
Lead Azide	Detonator or initiator	Pressed
Mercury Fulminate	Detonator or initiator	Pressed
Tetrytol	Burster charge	Cast
Pentolite	Bursting charge	Cast
PETN	Detonating cord (Primacord)	Pressed

FURTHER REFERENCES: TM 9-2900; FM 5-25; Ordnance Safety Manual; Picatinny Test, Vol. II.

Chapter 4

Explosive Trains

GENERAL.

During the study of ammunition, there is usually much discussion, and confusion, over the subject of explosive trains. In reality, those

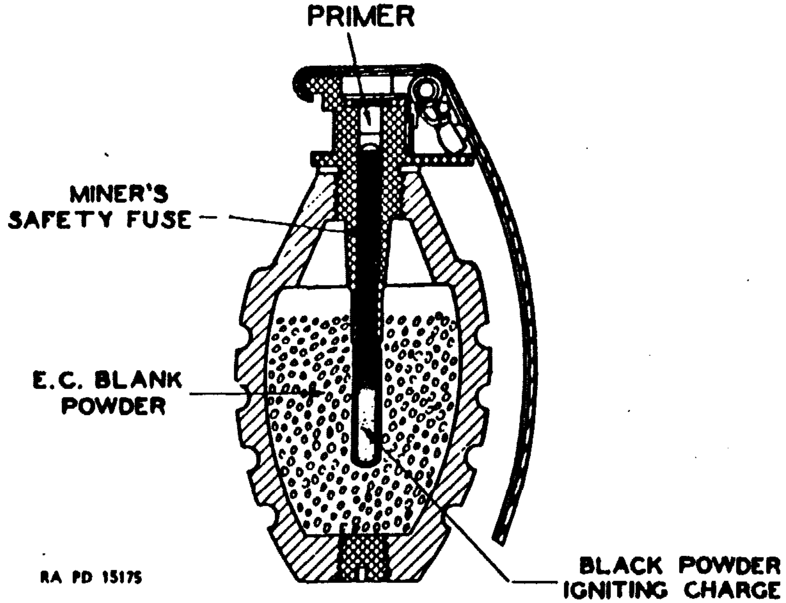


Figure 51 — Explosive Train Fragmentation Hand Grenade

explosive trains contained in ammunition are very simple; most of the confusion is a result of the numerous components which may be interposed in the basic train to gain the functioning desired from a particular train. An explosive train is nothing more than a series of explosions, the arrangement being such that control is gained over the explosions and the desired effect is accomplished.

Classes. There are numerous explosive trains found in ammunition, some of which are closely related and others which differ in many ways. Any of the explosive trains may, however, be roughly divided into one of the two general classes below:

I. PROPELLENT CHARGE EXPLOSIVE TRAINS.

A. Low-explosive Trains.

II. BURSTING CHARGE EXPLOSIVE TRAINS.

A. Low-explosive Trains.

B. High-explosive Trains.

In all explosive ammunition, one or both of the above trains will be found.

PROPELLENT CHARGE EXPLOSIVE TRAINS.

Small Arms. Propelling charge explosions are utilized to force the projectile from the weapon toward its target. A simple example

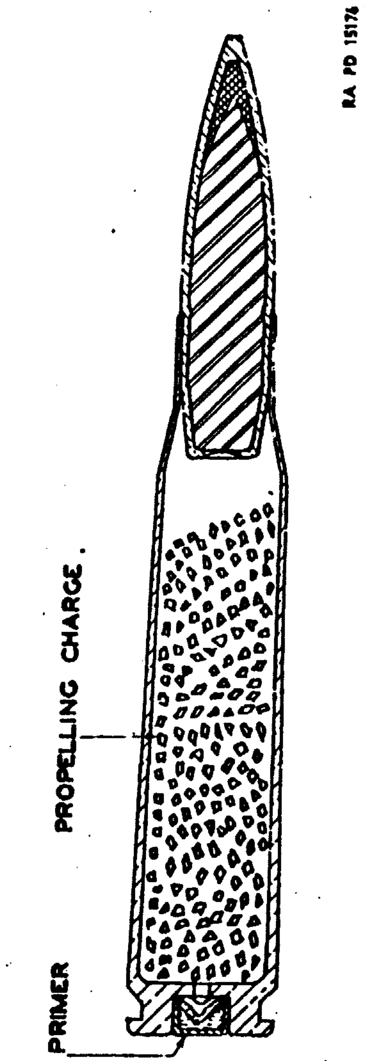


Figure 52 — Explosive Train Small-arms Cartridge

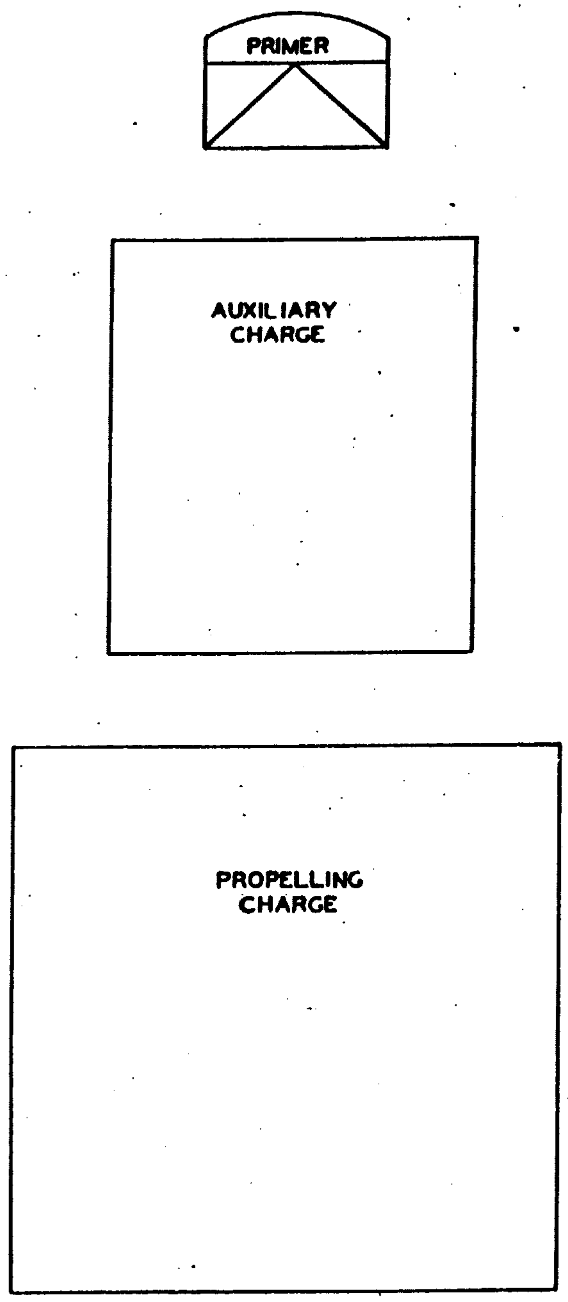


Figure 53 — Components Used in the Propelling Charge Explosive Train — Artillery Ammunition

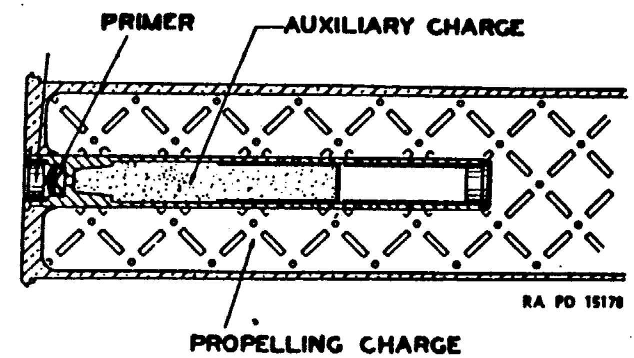


Figure 54 — Primer Showing Auxiliary Charge Contained in Primer Body

of this train is found in a round of small-arms ammunition (fig. 52). The components used in this train are a percussion primer and a propelling charge. The primer converts the mechanical energy received from the firing pin of the weapon into a flame. The flame passes

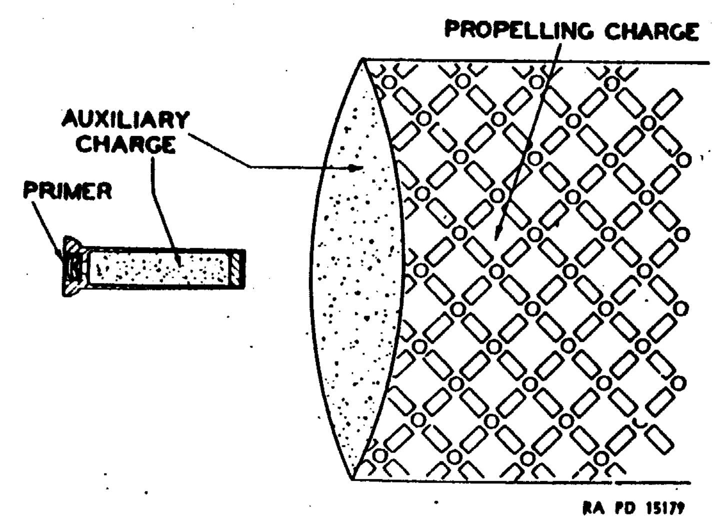


Figure 55 — Primer Showing Auxiliary Charge Divided Between Primer and Igniting Charge

through the vent leading to the powder chamber and ignites the propelling charge. The gases from the propelling charge explosion push the bullet out through the bore of the weapon. The train of explosions present in this series are the explosion of the primer and the explosion of the propelling charge.

Artillery. The propellent charge explosion of a round of artillery ammunition will show a slightly different train from the one in small-arms ammunition. In this train we have a primer and a propelling charge as illustrated (fig. 52), but in addition to these components, it is necessary to place an auxiliary charge of black powder between the primer and the propelling charge (fig. 53). The addition of the auxiliary charge is necessary because the small flame produced by the primer is not of sufficient intensity to properly initiate the large amount of propelling charge powder which is normally contained in a round of artillery ammunition.

The auxiliary charge may be contained in the body of the cannon primer, making an assembly of the primer and auxiliary charge (fig. 54), or it may be divided between the primer body and the igniter pad (fig. 55). In either case, its function is the same, the arrangement being such as to give the best ignition to the propelling charge. The series of explosions in this train are the explosion of the primer, auxiliary charge, and propellent charge.

BURSTING CHARGE EXPLOSIVE TRAINS.

General. Bursting charge explosive trains may be classified as high-explosive trains or as low-explosive trains. Shrapnel projectiles and fragmentation hand grenades are examples of those containing low-explosive trains. Rifle grenades, bombs, and artillery shell are examples of those containing high-explosive trains.

Low Explosive. In the case of shrapnel the components contained in the explosive train are a percussion primer, a powder time train of black powder, a magazine charge of black powder, and a base charge of black powder (fig. 56). The action is initiated by the firing pin within the fuze striking the primer, the flame thus set up is transmitted through the components named to the base charge. The explosion of the base charge forces the lead balls out of the body of the projectile.

The low-explosive train contained in the fragmentation hand grenade may be easily traced by reference to figure 51. The action of this train is started by a spring-driven firing pin striking the primer in the fuze. The flame from the primer is transmitted through a length of safety fuses to the black powder igniting charge at the end of the fuses. The explosion of the igniting charge initiates the action of the bursting charge of E. C. Blank Powder.

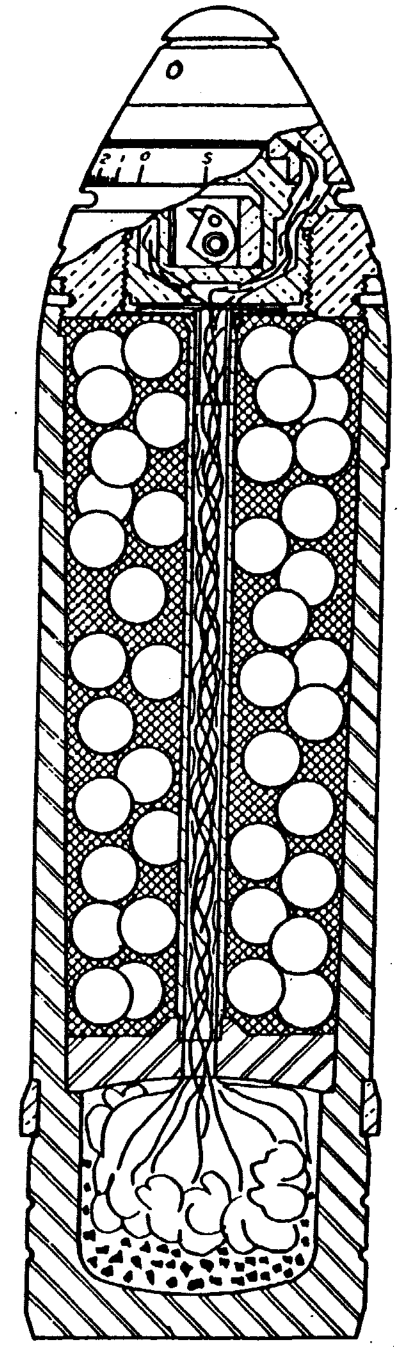


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Figure 56 — Explosive Train — Shrapnel Projectile

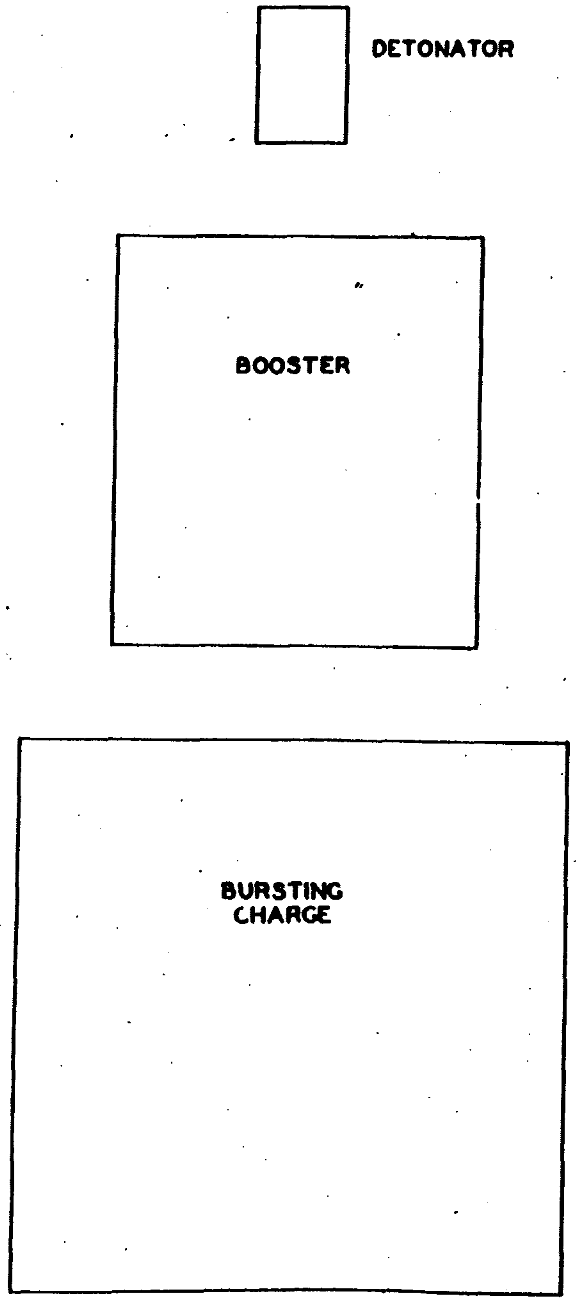

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Figure 57 — Basic Chain of Components — High-explosive Train

EXPLOSIVES

High Explosive. High-explosive trains are very simple basically, but as the need for various actions arise the train becomes complicated. If we remember the basic chain of components which must be present in all high explosive trains, the picture will be clearer (fig. 57). The basic chain of components which must be present in all high-explosive trains used in ammunition are:

1. A detonator.

2. A booster.

3. A bursting charge.

The detonator sets up a high-explosive wave when initiated by the stab action of a firing pin or a flame. This detonation is so small and weak that it will not initiate a high order detonation in the bursting charge unless a booster is placed between the two. The booster picks up the small explosive wave from the detonator and amplifies it to such an extent that the bursting charge is properly initiated (fig. 58).

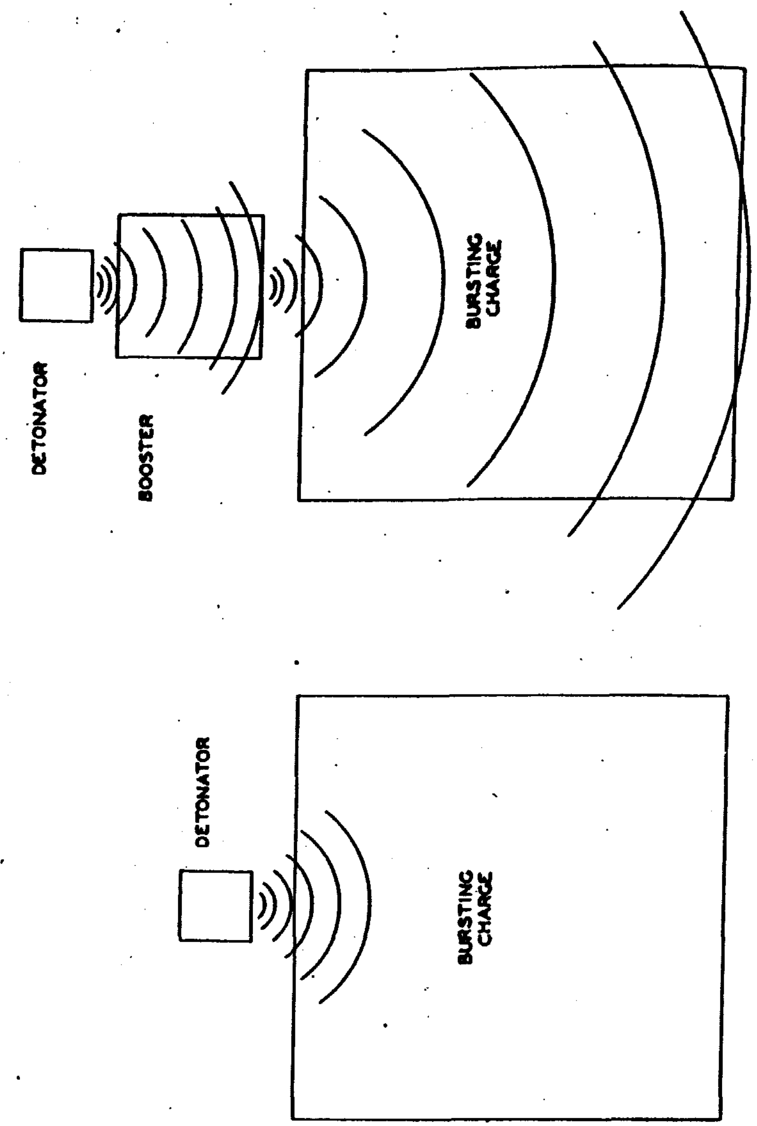
To gain the action necessary to control the time and place at which an explosive projectile will function, it is necessary to incorporate other components in the high-explosive train. The action desired may be a burst in the air, a burst instantly upon impact with the target, or a burst shortly after the projectile has penetrated the target. The components which may be used to give these various actions are a primer, a black powder delay pellet or train, an upper detonator, or any combination of these components arranged in such an order that the desired effect is gained. Regardless of the arrangement of the components the basic chain will remain the same, other components being placed in front of the basic chain.

THE HIGH-EXPLOSIVE TRAIN, COMPARISON OF THE BASIC STEPS

Step	Explosive	Cost Per Unit Weight	Amount Used	Sensitivity	Brisance
Detonator	Lead Azide or Mercury Fulminate	Most	Least	Most	Least
Booster	Tetryl	Intermediate	Intermediate	Intermediate	Most
Bursting Charge	TNT, Amatol, etc.	Least	Most	Least	Intermediate

The action for causing a projectile to burst in the air may be obtained by placing a primer, which is fired when the projectile leaves the weapon, and a black powder time train in front of the basic chain (fig. 59).

The primer is fired upon discharge from the weapon, thus igniting the time train rings. The time train rings burn for the length of time



RA PD 15182

Figure 58 — Detonator Wave Amplified by Use of Booster

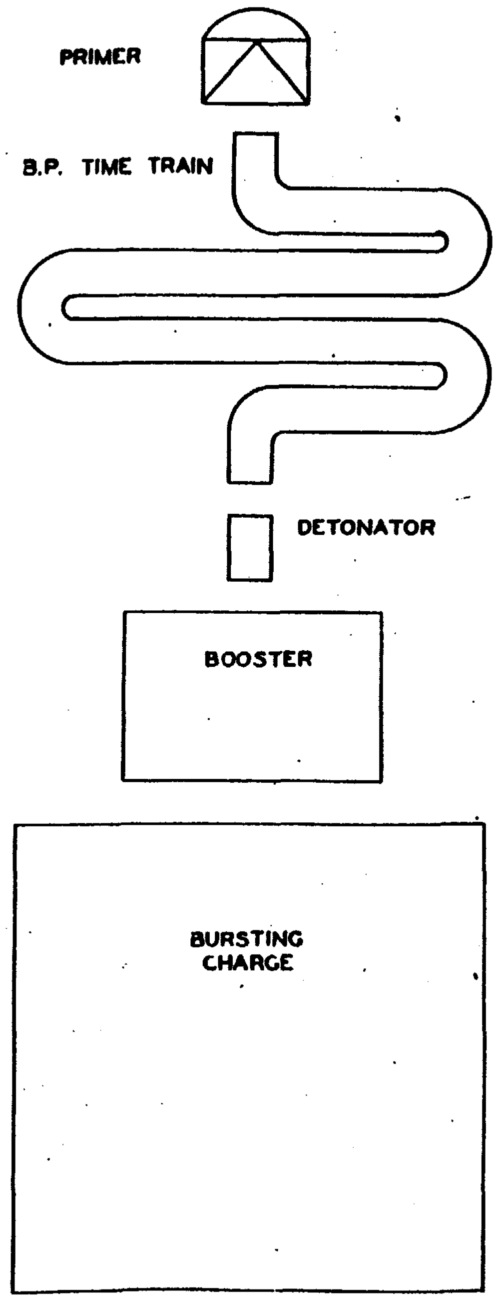


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Figure 59 — Arrangement of Components for Time Action

for which they were set previous to firing and then initiate the action of the detonator, booster, and bursting charge.

For bursting the projectile promptly upon impact with the target, a superquick or instantaneous action is necessary. This action is usually obtained by placing an upper detonator in the extreme front of the fuze and a lower detonator in the body near the booster charge (fig. 60). Upon impact with the target, the upper detonator is fired by the stab action of the firing pin which is set directly above it. The explosive wave thus started passes through the flash tube of the fuze to the lower detonator, to the booster, and in turn to the bursting charge. By placing an upper detonator in the extreme front of the fuze, the wave is started instantly upon impact and the mechanical problem of fuze design is greatly reduced.

To allow penetration of the target by the projectile, a delay action is necessary. This is obtained by placing a primer and a delay element ahead of the detonator (fig. 61). In some instances, this combination of primer and delay are inserted between an upper and a lower detonator. In such cases, the action starts off as a detonation, is converted into a flame by the primer, and into a detonation again by the lower detonator. In most cases, however, the action is started by the action of a firing pin on the primer without the use of an upper detonator.

It may be noticed that no mention has been made of mechanical actions utilized to effect bursting in the air. Action produced by mechanical means is not a part of the explosive train, hence only time action derived from explosive action is given.

Chemical Shell. A variation of the high-explosive train is found in chemical shell. In this train, there is no large bursting charge such as is found in high-explosive shell as it is only necessary to rupture the shell case and allow the chemical contents to escape. The actual bursting or rupturing of the shell is accomplished by the booster or an auxiliary booster charge. The boosters contained in chemical shells are usually larger than those contained in high-explosive shell of corresponding size. In chemical shell of more recent design, the shell body is ruptured by an added component called the burster. The components contained in the explosive train of the older type chemical shell are the detonator, usually upper and lower as superquick action is needed, and a booster.

The components used in the newer type chemical shell are the detonator, usually upper and lower, a booster, and a burster. The burster is a charge of tetryl which is contained in a thin aluminum case. This charge extends through the chemical filler to the base of the shell body. Upon functioning, a better rupturing effect is obtained than with the older type in which all of the explosive charge was concentrated in the nose of the shell.

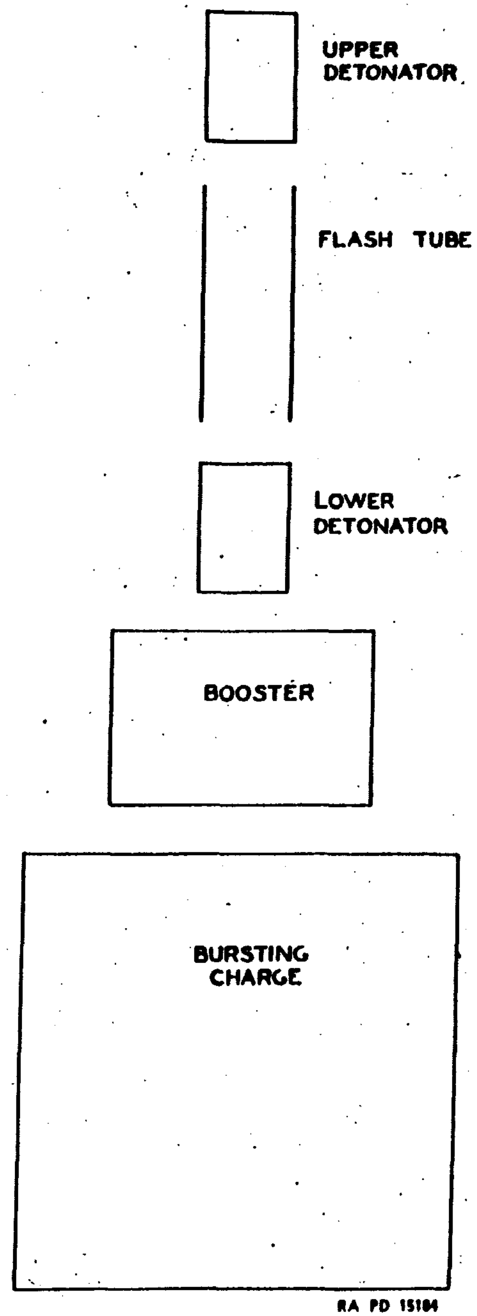

Figure 60 — Arrangement of Components for Superquick Action

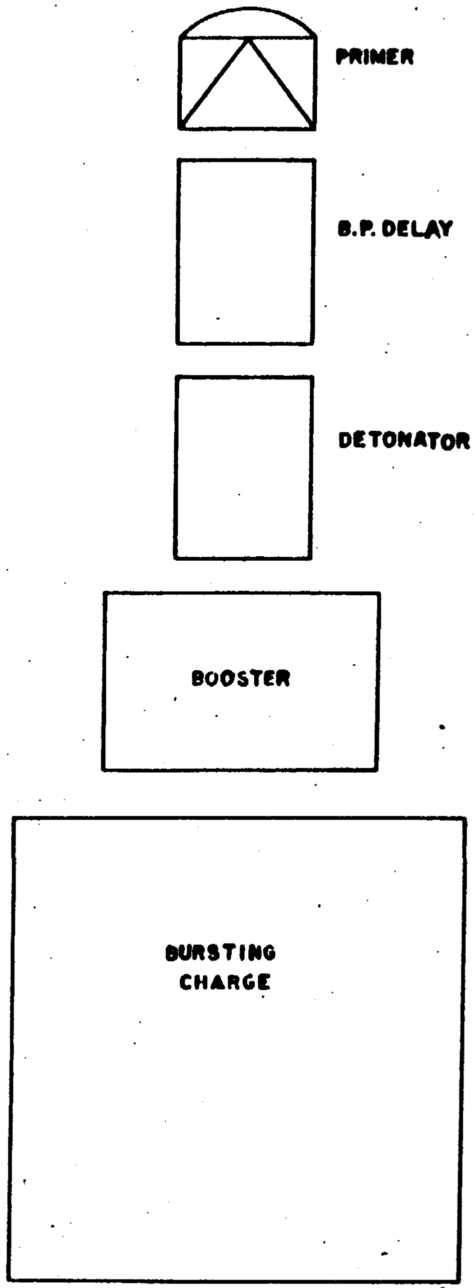

Figure 61 — Arrangement of Components for Delay Action

DUDS AND LOW ORDER DETONATIONS.

General. In considering the high-explosive bursting charge trains, it is taken for granted that the explosives would function properly. Occasionally, however, a dud or low order detonation may occur.

Duds. A dud is said to occur when a shell fails to explode. This condition is the result of a component which fails to function, or fails to completely function.

A dud can result from many causes which are often inherent in the high-explosive bursting train. Some of these can be listed as follows:

1. Improper initiation.

2. Deterioration of one component.

3. Poor contact between the steps of the train.

4. Omission of a component.

5. Foreign materials obstructing the function of a mechanical component which takes part in the action of the explosive train.

Low Order Detonation. A low order detonation is said to occur when the shell explodes incompletely. The detonation is in the nature of a burning instead of a shattering wave. It is well to note, in contradistinction to a dud, a low order detonation is the result of a component functioning completely but improperly. The detonating wave is slowed down.

A low order detonation in the high-explosive bursting train will result from the following causes:

1. Improper initiation.

2. Deterioration of one component.

3. Poor contact between the steps of the explosive train.

4. Low density of the shell filler.

5. Exudation.

A low order detonation can be detected in the following manner:

1. By the low report produced after the shell has exploded.

2. By the color of the smoke produced; for example:

Explosive	Color of Smoke for High Order Detonation	Color of Smoke for Low Order Detonation
TNT	Black	White
50/50 Amatol	Black	White
Explosive D	Black	Yellow
80/20 Amatol	White	White

3. Examination of shell body; unexploded fragments of explosive. The shell body may be split instead of properly shattered into efficient fragments.

CONCLUSION.

In conclusion, it may be well to reiterate that each and every element must function properly or the entire round of ammunition is lost. *If a 5 cent primer fails to function, not only may a shell costing hundreds of dollars be wasted, but a life may be lost, or perhaps even the results of battle may be determined.*

Chapter 5
Exudation

GENERAL.

Shortly after World War I, when large amounts of TNT and amatol loaded shell were stored, it was noticed that the TNT and 50/50 amatol loaded shell seemed to be undergoing some sort of deterioration evidenced by the emission of an oily, tarry material and, in some cases, a gas. Because of the large number of shells showing this deterioration, it was considered a serious problem and immediately an investigation was begun. As a result of that investigation, it was possible to arrive at conclusions as to the various causes for exudation, the remedies, and also the effect of exudation upon serviceability of the shell.

CAUSES.

The principal causes of exudation were found to be of two types, physical and chemical. These causes are:

1. The presence of impurities in the TNT as a result of manufacture.

2. The use of alcohol shellac in the booster cavity, and alcohol for cleaning threads in the nose of shell. Also, the occasional use of alcohol for recrystallizing TNT in the "purification" process.

3. The introduction of impurities by the ammomium nitrate used for amatols whose compositions are:

(50/50)—NH_4NO_3, 50 percent; TNT 50 percent by weight
(80/20)—NH_4NO_3, 80 percent; TNT 20 percent by weight

Impurities in TNT as a Result of Manufacture. The first cause, of manufacturing impurities, is a physical cause. The manufacture of TNT involves the reaction of toluene with nitric and sulfuric acids, to form trinitrotoluene. This reaction is controlled by the close control of temperatures and concentration of the acids.

However, even with the best possible control of conditions, it is still impossible to completely control side reactions, which are demonstrated below.

If A and B are the raw materials and C is the product desired, $A + B = C$ should be the reaction.

However, in organic reactions, C is very often only one of several

possible products, so that while C may be the product preponderantly formed, another or several other products may be formed in small amounts, as indicated by

$$A + B = C \text{ (99 percent)}$$
$$\text{D, E, (1 percent)}$$

Furthermore, it can be seen that if the materials A and B do not react completely, the final product will also have them in it, as an impurity, so that where we originally started to prepare pure C, we have ended up with a mixture of A, B, C, D, E, etc. down the alphabet.

Although these impurities are present in only small quantities, they still exert an appreciable influence on the properties of the final product.

In the case of TNT, the manufacturing impurities usually consist of incompletely reacted material such as dinitrotoluene, and the isomers of TNT, that is, those materials which have the same compositions, but in which the molecules are arranged in a different fashion.

Close control of conditions cuts those down to a minimum. However, during World War I, the grades of TNT used were of a low degree of purity as determined by melting point (or setting point) indicating sizable amounts of impurities.

To indicate the effect of these impurities, one can recall sprinkling salt on ice to lower the melting point, thus causing it to liquefy where ordinary water would be frozen. The DNT and isomers have the *same affect on the TNT, that is, they lower the melting point.* Chemically pure TNT melts at 80.75 C. Impure TNT may melt at as low a temperature as 76 C. In the center portion of the cast is the part that solidifies last, because the metal walls of the shell cool the outside rapidly.

For the reason indicated above, any impurities would tend to concentrate in the center core because they solidify at a lower temperature. In these areas, the impurities and TNT form low melting point mixtures, and if the shell should be exposed to elevated temperatures, even such as are reached in the southern parts of the United States, these low-melting point areas will liquefy and, due to expansion, will force their way out through the booster cavity. Note that this is a purely physical process; no gas is liberated and no reaction occurs. The remedy obviously is to use only high purity TNT. It has been found that TNT with setting point of 80.2 C or higher gave no exudation trouble.

Introduction of Alcohol Into the TNT. It will be noted that the cause of exudation discussed above creates no gas. Since gas is present in some cases, further investigation was made to determine its source. The gas liberated was found to be ethyl nitrite, which caused the investigators to suspect ethyl alcohol which was used for cleaning, and sometimes for "purification" of the TNT. By actual laboratory experiments, they were able to prove that TNT and alcohol react, and they prepared in this manner the same material that exuded from the shell. It will be noted that this is a chemical reaction.

To overcome this, the use of alcohol shellac for strengthening the booster cavity and alcohol for washing the threads on the nose, was discontinued, and acetone was substituted. Furthermore, the Army Specifications were revised to prohibit use of alcohol in recrystallization of TNT.

Introduction of Impurities by Ammonium Nitrate in Amatol. The third cause of exudation has been found in the case of the amatols. Ammonium nitrate as commonly prepared, is made from the ammonia that is liberated in the destructive distillation of coal. It is a byproduct, and contains as impurities many of the organic breakdown products such as pyridine. These had been found to act in a fashion similar to alcohol. The remedy is purification of the ammonium nitrate or the use of ammonium nitrate which is prepared in a different way, from pure products. The latter is a good deal more expensive, and purification of the byproduct NH_4NO_3 is usually practiced.

It was noted by the investigators, that 50/50 amatol exuded while 80/20 amatol showed only rare cases of exudation. This was because of the small amount of TNT and because the ammonium nitrate itself absorbed most of the exudate.

One final problem arose which was baffling for some time. Some samples of exudate showed red particles of an explosive compound which was found to contain iron. It was shown that when alcohol and TNT reacted in the presence of iron, this red material was formed. The iron came from corrosion of the shell case by the exudate in the case of TNT shell, or by moisture in the ammonium nitrate.

Several methods have been introduced to avoid this. One method is coating the shell inside with an acidproof paint. The other is controlling the moisture of the NH_4NO_3. Another is a TNT pour on top of the amatol, called a booster-surround. The purpose of this is to seal the hygroscopic ammonium nitrate from moisture.

EFFECTS OF EXUDATION.

Fire Hazard. Since the exudate from TNT shell carries TNT, and in some cases the explosive red iron compound with it, it is inadvisable to have it on the floor of a magazine. It is washed away with hot water as soon as it is found. Regulations require a monthly inspection of magazines containing shell and bombs, and one of the purposes of this inspection is to find exudation and have it cleaned up. Bulk TNT will not exude.

Corrosion of Shell. Since exudate is often acid in reaction, it corrodes the unprotected shell case and booster. When exudation is found, the booster is removed and the cavity is cleaned. It may be necessary to have this done regularly. Fortunately, however, this condition is unlikely to be found in modern ammunition so that it is only in war reserve ammunition that it may prevail.

Cavitation. Cavities in the filler are often another result of exudation. They may cause trouble in two ways. First, by desensitizing the booster or the surrounding charge; and, second, by lowering the density of loading, thereby decreasing the efficiency of the shell, somewhat. The exudate contains some TNT, but is very much less sensitive to detonation, so that the booster has a smaller chance of causing a high order detonation when initiated by a Mark III fuze, for example. However, it has been found that the M46 fuze which has what is called a "Horse Detonator" compensates both for desensitization of the booster and of the bursting charge, and gives consistently high order detonations with the worst exuding shell that can be found.

It was assumed at one time that cavitation was dangerous, since during setback a premature might occur because of the crushing of one piece of TNT against another, or against the shell wall, or pinching of TNT exudate in booster threads. This was tested in 75-mm and 155-mm shell in a very bad state of deterioration from exudation. They were fired at 12 percent excess pressure to make the worst possible combination of conditions. No prematures resulted either in the gun or along the trajectory. It was, therefore, concluded that for these two types of shell it was safe to use the exuding shell. The restriction on their use was therefore removed and they are cleaned with acetone and painted, when necessary, for morale. The issue of exuding shell is given priority for training purposes with a view to expending them.

Chapter 6
High-explosive Loading

GENERAL.

In the consideration of high-explosive loading, it is well to note that once a suitable bursting charge has been developed, the next important step is to load it into the projectile or bomb cavity at the proper density. Uniform density of loading is desired for the following reasons:

Low or nonuniform density of the charge in a shell will cause it to "set back" on being fired, and "set forward" on impact. This might possibly leave a void around the fuze or booster at the instant of functioning and result in a "dud" or "low order" detonation.

Voids or areas of low density within the explosive charge may cause a "dying out" of the detonating wave, resulting in the explosion of only a portion of the charge. This is also generally referred to as a "low order" detonation.

Internal stresses combined with frictional heat from "set back" on firing a high-explosive shell of low or nonuniform density is the cause of premature explosions of shells while still in the gun barrel (with resultant loss of life and materiel).

It may be said that practically all loading operations are made with a definite aim in view; to completely fill the shell and bomb cavities with high explosive to a predetermined satisfactory density in a safe and uniform manner.

TRINITROTOLUENE (TNT).

Melting. TNT is supplied to loading plants packed in paper-lined wooden boxes in the form of finely divided flakes or crystals. It varies in color from light yellow to buff. Grade I TNT has a minimum setting point of 80.2 C and Grade II has a minimum setting point of 76.0 C. NOTE: At the present time, Grade I TNT is being used exclusively in loading operations. It has been definitely determined that the exudation of oily liquids from shells and bombs loaded in the past was due principally to the residual impurities in Grade II TNT. The fact that TNT melts at a temperature less than the boiling point of water gives it a great advantage over most other high explosives since it facilitates its manipulation for shell filling permitting it to be melted in steam jacketed kettles or on low-pressure steam coils. The melt unit employs steam pressure not to exceed 5 pounds. To insure this, an 11 foot water column or "leg" (open at the top) is connected to the incoming steam line feeding the melt unit. Should the pressure at any time exceed 5 pounds, this water column will be blown out, releasing the incoming steam to the atmosphere. Prior to melting, flake or crystalline TNT is run through a ⅛-inch mesh sieve to remove all splinters, nails, lumps and extraneous material. The screen for flake TNT has oblong openings approximately ⅛ inch by ½ inch.

Another great advantage of TNT, is that it does not corrode the metal parts of ammunition or form sensitive compounds with metals over long periods of storage. Each shell or bomb, however, is carefully inspected for condition before loading. Interiors must be clean and free of rust, scale, chips, grease, etc. A coating of black acidproof paint is customary for all interiors, and this must be thoroughly dry before loading. NOTE: In some instances where shell are loaded with TNT immediately after shot blasting the interiors, this paint is omitted.

Precooling. TNT is loaded by means of the casting method; that is, it is poured directly into the shell or bomb cavity and allowed to solidify. The principal difficulty encountered in loading this material is to obtain a solid cast of uniform density. TNT when passing from the molten to the solid state contracts approximately 8 percent in volume, and it is necessary to take care of this contraction in some manner in order to overcome the cavities which will be produced by normal shrinkage of the charge. The first step to overcome this cavitation is to cool the molten TNT to between 79 C and 80.5 C, or to the point where fine crystals appear in the molten mass. This cooling process is done in large metal tubs provided for the purpose. As an additional precaution to remove foreign materials, the molten TNT is drawn off from the melt unit into the cooling tubs through a suitable 18-mesh brass or aluminum screen. Cooling is accelerated by mechanical agitation; by hand, with a wooden or aluminum paddle; or both. The molten TNT is stirred continuously during the cooling period. Mechanical agitation is recommended for preliminary cooling point as tubs can be set under hoods and fumes exhausted. (TNT fumes become very toxic over long periods of exposure.) As the molten mass approaches the proper temperature, it should be carefully observed in a good light to note the formation of the fine crystals which reflect the light much like tiny flakes of gold leaf. The trained eye of an experienced operator will be found entirely adequate to determine when the molten mass is ready for casting. In this manner, the amount of contraction which occurs in the shell is reduced nearly 50 percent. While this cooling reduces the amount of cavitation, it also reduces the cooling time required in the shell itself.

Pouring. Shells are filled either in one pour, or more than one pour, depending on their size and shape. The one-pour operation will be considered first and is described as follows:

Inspect the shell cavity to insure it is clean, evenly coated with black acidproof paint, and thoroughly dry.

Insert a suitable funnel and pour in the molten TNT, filling the funnel approximately three-quarters full.

The TNT first solidifies on the shell bottom and sides (fig. 62), and then forms a crust over the top surface of the liquid in the funnel. As the charge solidifies, contraction occurs causing the liquid in the funnel to recede into the shell, forming a cavity under the top crust in the funnel (fig. 63). No cavities will be formed in the shell charge, provided there is enough liquid TNT in the funnel to take care of all shrinkage in the shell charge, and provided the liquid TNT in the funnel is allowed to flow to all parts of the shell charge where shrinkage is taking place. A good example of this is shown in figure

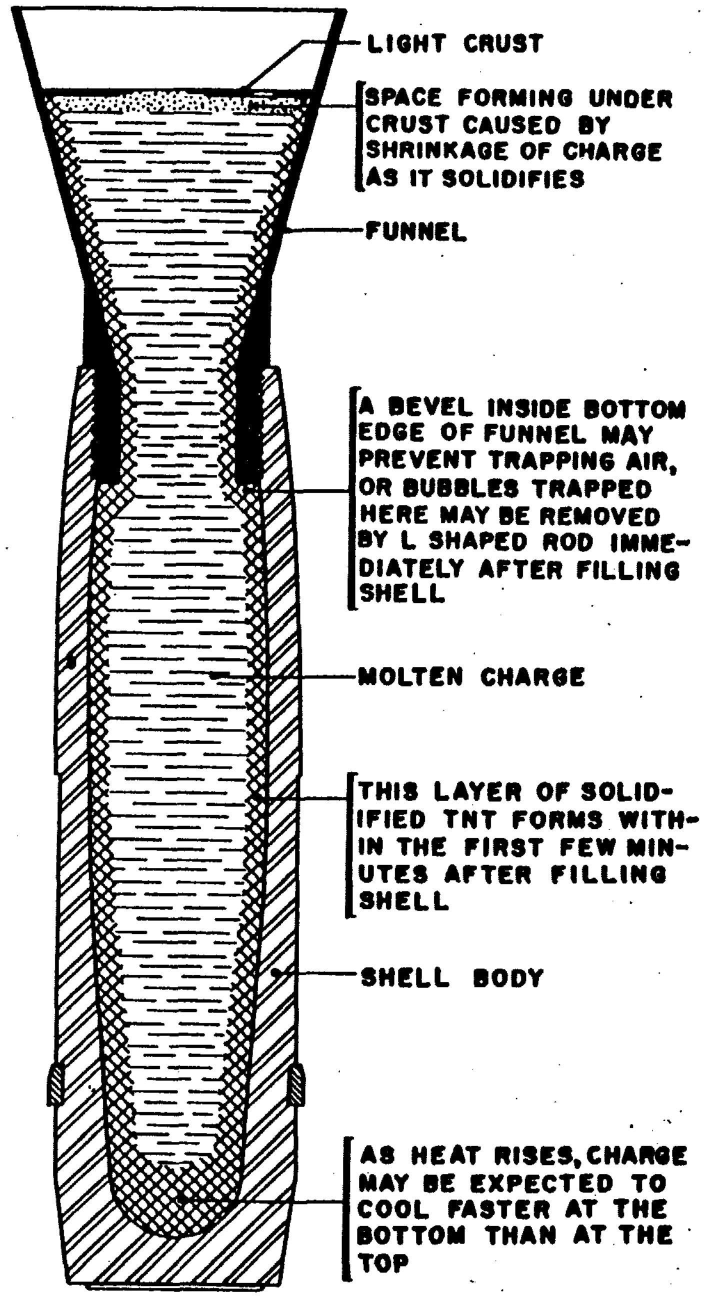

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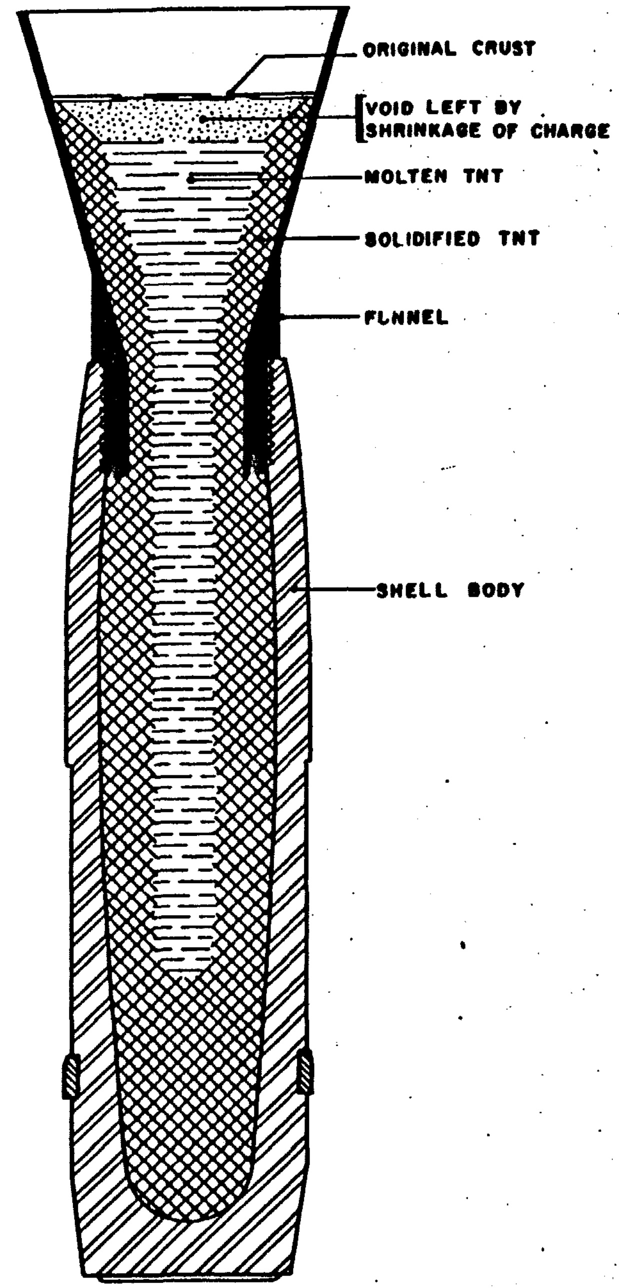
Figure 62 — Shell Immediately After Loading (One Pour)



RA PD 15187

Figure 63 — TNT Solidifying in Shell (One Pour)

64. All cavities due to shrinkage have been formed in the funnel which is now loosened by a light tap and lifted out of the shell.

The principal cause of cavitation in the shell charge is illustrated by figures 65 and 66. In this case, cooling takes place more rapidly in the neck of the funnel than in the shell below and the TNT finally "freezes" solid at this point. The liquid TNT in the funnel can no longer flow into the shell and all further shrinkage that takes place below this point results in a central cavity or "pipe" in the shell charge. Three possible causes of this are:

The inside diameter of the funnel may be too small at the neck.

The funnel may be made of material that radiates heat too rapidly.

The outside circulation of cold air may be causing rapid cooling at this point.

This condition may be corrected by:

Redesigning the funnel to enlarge the inside diameter of the neck.

The use of approved plastic funnels which are relatively poor conductors of heat.

The insulation of shells and funnels by hoods, baffles, or other protection from drafts to prevent rapid cooling of the top portion of shell.

The size and shape of some of the larger shell is such that it is impracticable to obtain a suitable cast in one pour. When the opening in the nose is of considerably smaller diameter than the shell cavity, the TNT will freeze solid at this point long before the rest of the charge has had time to cool. This difficulty is overcome by partially filling the shell and allowing it to cool sufficiently before adding a second or final pour. The casting of a 155-mm H. E. shell is described as follows:

The shell is filled approximately two-thirds full and allowed to cool until a thin crust has formed. The crust is then cut into small pieces with a chisel pointed half-inch brass rod approximately 18 inches long. The crust is carefully cut away from the sides leaving a round hole with no projecting ledges. Trained operators continue cutting back the crust as it forms, carefully noting the condition of the molten mass. As the molten core in the center of the shell grows smaller in diameter, care must be exercised not to allow heavy or large pieces of crust to fall in and choke it up, as a cavity will form in the molten core below the choke point. When the center hole in the cast has reduced to about 1 inch in diameter, and the molten TNT has reached a consistency of thin mush, the second pour should be added by filling the shell to within approximately 2 inches from the top. As the second pour is added, care must be exercised to be sure there is no crust over the molten core of the first pour. An operator should precede the bucket man and cut the crust in each shell with a brass rod a few seconds before the second pour is added.

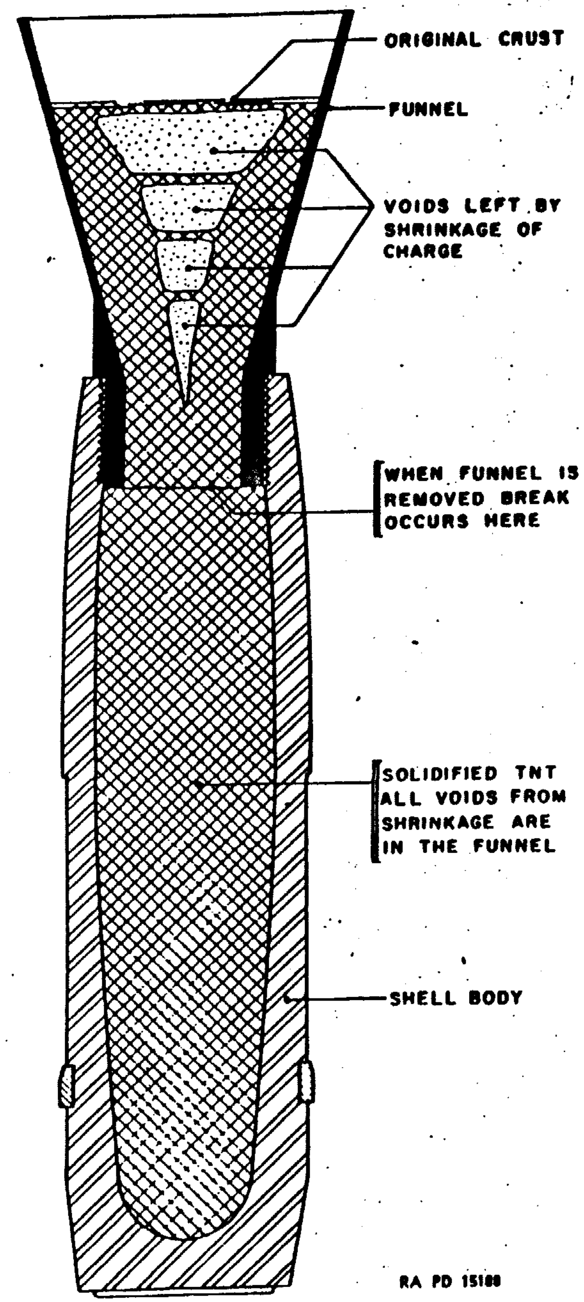


Figure 64 — Shell Properly Loaded — Cavity in Funnel

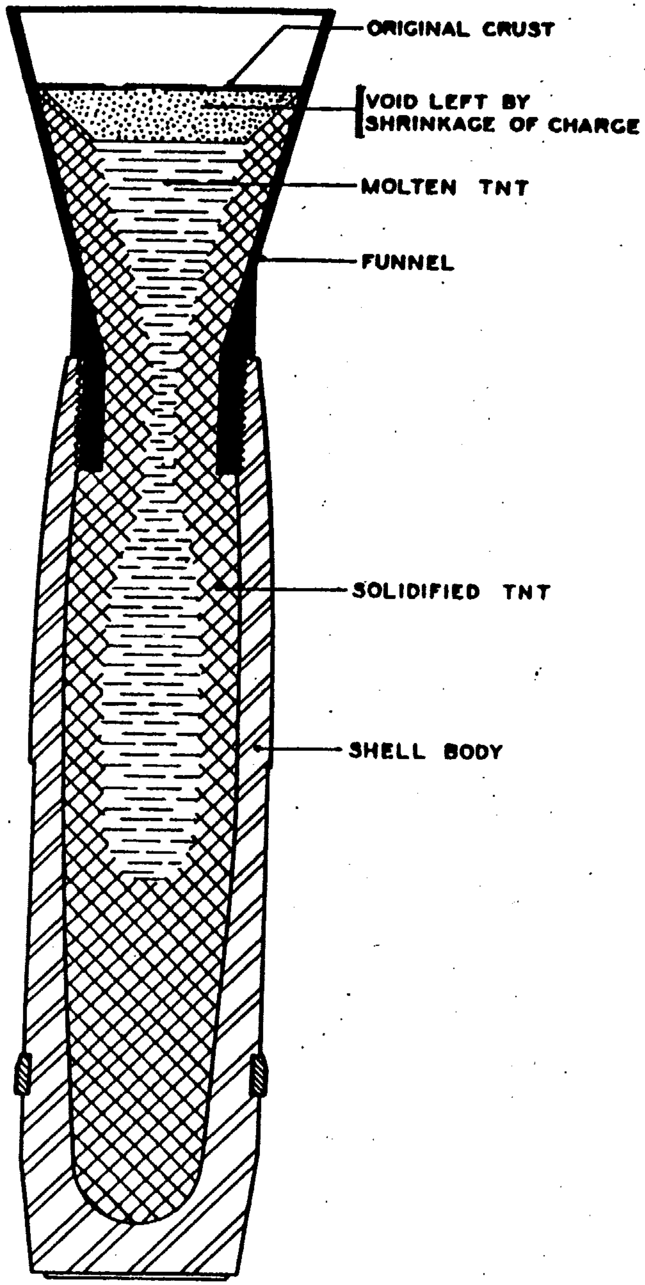


Figure 65 — Cavity Forming in Shell

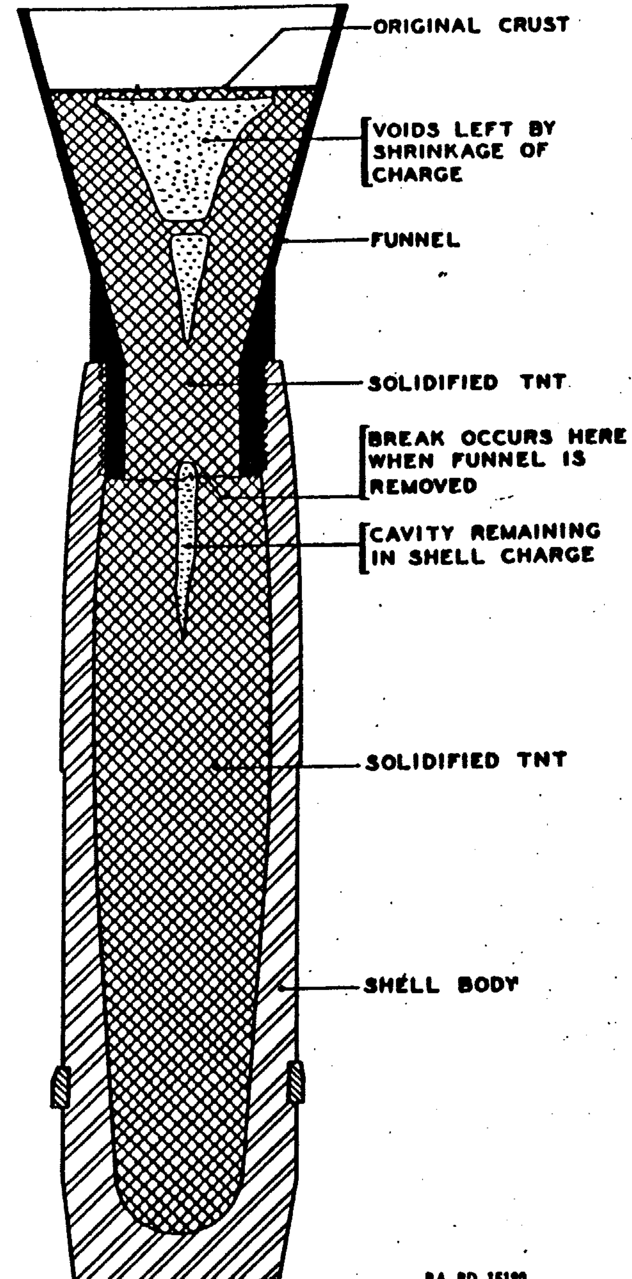
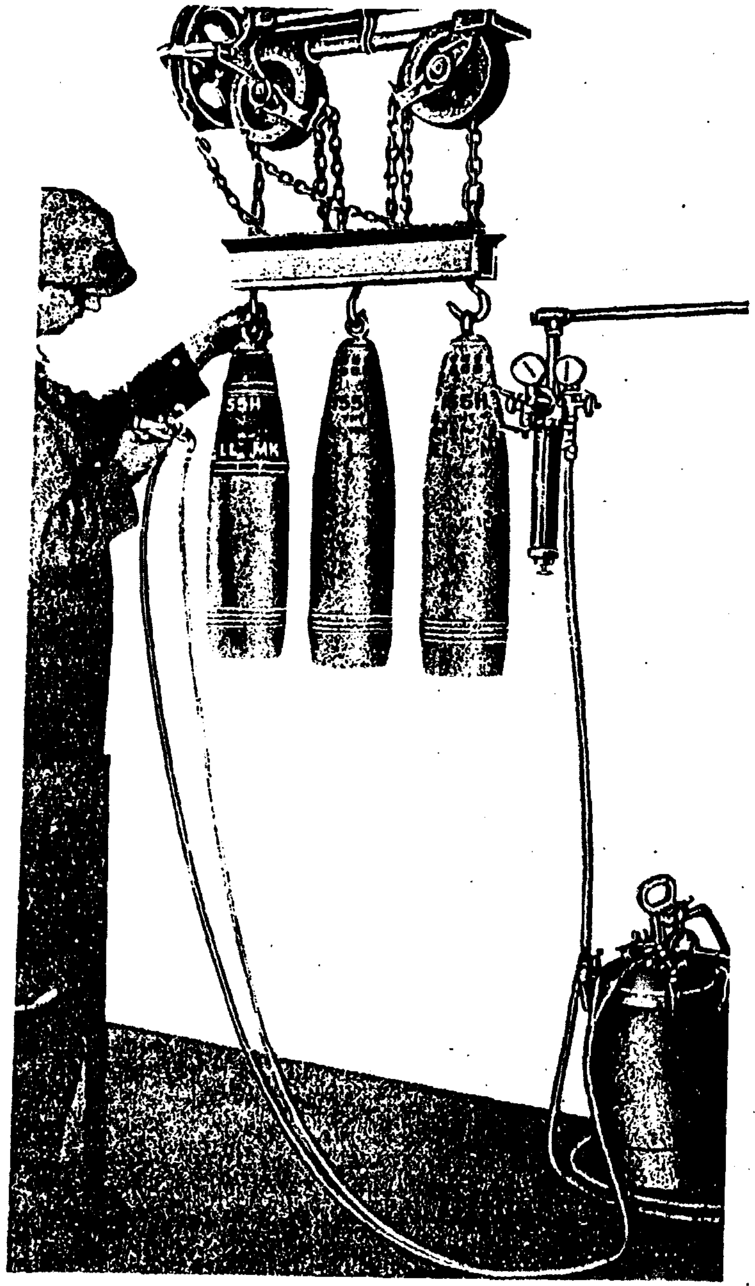


Figure 66 — Shell Improperly Loaded — Cavity or Pipe Formed Near Neck of Shell



RA PD 15191

Figure 67 — Stenciling 155-mm Shells

Continue cutting the crust on the second pour in the same manner as described for the first. More care must be used as the molten core in the center is smaller now and can be more easily choked with dry chips falling into it. Keep it cut back and open in exactly the same manner as described for the first pour. Carefully watch the consistency of the molten mass as it will probably cool much faster than the first pour. When the central core has reduced to about 1 inch in diameter, and the molten TNT is the consistency of thin mush, the shells are ready to be topped off. This is done by inserting a large funnel to protect the threads and with enough volume to act as a riser. (If no other means of protecting the threads is used, this funnel remains in the shell during all previous operations.) The same care must be exercised in adding the top off pour as was used in adding the second pour to break up any crust on top of the molten core in the shell. An operator should precede the bucket man and cut the crust in each shell with a brass rod a few seconds before the top-off pour is added.

Fill the funnel approximately three-quarters full and allow to cool. If previous instructions have been followed, all shrinkage that takes place from now on in the shell will be filled from the reservoir of molten TNT in the riser and solid cast shell of uniform density will result. Common practice is to break the crust that forms on top of the funnel during the cooling period, but this is not necessary, and may even be harmful because if a a solid chip falls into and chokes the narrow molten central core, a cavity will form in the shell below the choked point.

Housekeeping. To assist in keeping the exterior of the shells and pouring room floor free of TNT, spilled during operations, a paper mat may be spread over the shells cutting openings for the insertion of each funnel. As an alternate, brass mats may be used with suitable openings for the nose of each shell. If a brass mat is used, it should be wiped very lightly with a half mixture of kerosene and paraffin oil to prevent the TNT from adhering to it. This liquid mixture is also excellent for treating pouring from floors and any metal or cement surface likely to become splashed with molten TNT, as it prevents the TNT from sticking. Rubber pouring buckets of soft latex have been found excellent for pouring TNT into shell as the bucket can be quickly collapsed by the operator as soon as it is empty (while still hot), causing the film of TNT adhering to the inside to flake off for reuse. Pouring funnels made of approved molded plastic material have also been found highly satisfactory. These are made to extend well into the shell nose protecting the threads during the casting period.

Drilling. Booster cavities are drilled, using a horizontal drill or other suitable means to produce a booster cavity which will conform to that shown on the loading drawing. A twist drill of high-speed steel has been found to be very satisfactory for this operation. Recommended maximum speed for horizontal drilling machines is 120 revolutions per minute. All explosive must be removed from the threads of shells, using a bronze pick while the shell is rotated on a rotating device. All loose particles of explosive must be removed from the booster cavity. This is usually accomplished by a vacuum unit approved for use in hazardous operations. All explosive must be removed from the exterior of the shell using a bronze scraper. Shells which have been carelessly loaded will usually have a cavity or pipe extending into the charge below the bottom of the booster cavity. This condition should be carefully watched for at this point in the operations, and such shell set aside pending decision of the inspector.

Determination of Specific Gravity. For the determination of specific gravity (density) of the charge, there shall be selected one empty bomb or shell from each 100 to be loaded. Each sample selected shall be marked so that it can be identified after loading. The test shall be accomplished as follows: Weigh each sample bomb or shell empty and then fill with water, making allowance for space occupied by fuze, booster, and weight of auxiliary boosters (if any). Weigh each water-filled sample, then empty, and throughly dry for loading. At the rate of 1 per 100, these samples will be loaded under conditions identical in all respects with those employed in loading other bombs or shells. After loading weigh each sample and calculate the specific gravity of the charge as follows:

$$\text{Specific Gravity} = \frac{W_t - W_e}{W_w - W_e}$$

W_e = weight of empty shell in pounds
W_w = weight of water-filled shell in pounds
W_t = weight of loaded shell in pounds

If the specifiic gravity complies with the requirements, the identification markings may be removed and the samples included in the lot. The specific gravity of the TNT charge shall not be less than 1.54. If the specific gravity falls below this requirement the 100 shells or bombs represented by the sample will be held pending final decision of the inspector as to the cause of the low density.

Splits. A visual examination of the charge is made as follows: The United States shall provide one or more empty shells or bombs of the type being loaded which shall be made into molds by halving longitudinally. These halves shall be held together with bands or other means and a gasket to prevent leaks while loading. From time to time at the discretion of the inspector, and especially at the beginning of loading operations, these split bombs or shells shall be filled under conditions identical in all respects employed during regular operations. After the charge has cooled, it is removed and examined

by the inspector to enable him to judge whether there is any objectionable cavitation or other defects. The molded charge is usually split longitudinally by sawing with an ordinary hand saw. If the conditions exhibited by the sectional charges are not satisfactory, steps shall be taken immediately to remedy the faults that have been disclosed. Additional valuable data may also be gained if water weight determination of density is taken on all splits as described above.

AMATOL.

General. Amatol is a mixture of TNT and ammonium nitrate. The percentage of each is determined by weight and may be mixed in proportions varying from 50/50 to 80/20, the latter figure in each case representing the percentage of TNT. Ammonium nitrate is a white crystalline material which when finely ground, resembles table salt in appearance. When pure and dry it melts at 170 C. (Compare this with TNT.) Its chief drawback is that it is very hygroscopic, quickly taking up moisture from the air. For this reason, amatol must be carefully sealed from the atmosphere. Unlike TNT, amatol has quite a corrosive effect on metals especially if moisture is present. The great value of ammonium nitrate is that it opens an enormous supply of an easily procurable and cheap material, practically non-explosive by itself, which when mixed with as little as 20 percent of TNT provides an explosive practically of the same brisance as TNT alone. The available supplies of TNT can therefore provide a far larger quantity of high-explosive ammunition than would be possible without the use of ammonium nitrate. When mixed with various percentages of TNT, it will flow in the molten state and can be loaded by casting. When only 20 percent TNT is mixed with 80 percent nitrate (80/20), the mass is too stiff to pour and must be extruded or tamped while hot into the shell or bomb cavities.

Casting Method of Loading Amatol. When ammonium nitrate is received in hermetically sealed containers, it is fed directly into a sifter to screen it to the proper size. Lumps which fail to pass the screen are shoveled into a rotary nitrate cutter and thence back into the screen. The screened nitrate is placed in 50-pound covered buckets and taken to the mixing house and elevated to the third floor level. After carefully weighing, a charge of nitrate (approx. 800 lb) is placed in a steam jacketed rotary mixer known as a preheater where its temperature is raised to 82.1 C (180 F). This requires approximately 45 minutes.

In the meantime, a charge of TNT is being melted in a melt unit on the second floor (same as that used in TNT loading). The weight of this charge is such that when mixed with the charge of nitrate, the desired percentage of each will result. When all the TNT has melted, it is drawn off into a steam jacketed mixing kettle equipped with a mechanical agitator and kept at a temperautre of 85 C (184 F). The agitator is started and the operator opens a valve which allows the hot nitrate from the preheater on the third floor above to feed slowly into the molten kettle of TNT where it is thoroughly mixed and blended by the agitators. The dryness of the nitrate is essential, as with moist nitrate the amatol does not flow well or mix well, the moist nitrate crystals collecting together as lumps. Specifications require that ammonium nitrate contain not more than 0.25 percent moisture. After the entire charge of nitrate has been added, the blending and mixing in the kettle is allowed to continue until the entire charge appears to be fluid and no lumps of nitrate appear. For bombs which are to be loaded with approximately 60/40 amatol, it is desired that the amatol contain as high a percentage of ammonium nitrate as possible and still flow from the mixing kettle. This percentage depends on the fineness of the ammonium nitrate and may vary from 55 to 65 percent. The amount of ammonium nitrate used may vary from batch to batch and no attempt should be made to hold a uniform percentage. The amount used in each batch will be determined by the fluidity of the mix. The addition of ammonium nitrate to the molten TNT should stop at the point where the mixture will flow from the mixing kettle and at the point where the addition of more ammonium nitrate would prevent the mixture flowing from the mixing kettle.

From this point, the molten amatol is cast in the same manner as described for TNT, except for the fact that amatol is usually loaded with one pour, cooled until the central core is about ready to set up or has become "mushy," and topped off with TNT, using a riser as in the case of other TNT loading. This provides a TNT surround for the booster, seals the charge of amatol against moisture, and prevents corrosion of the booster case which would otherwise occur if it were in direct contact with the amatol. The interiors of all shells and bombs are given a coating of black acidproof paint prior to loading with amatol.

In the case of bombs which have both nose and tail fuzes, it is necessary to provide a TNT surround in both nose and tail to protect the fuze cavities from corrosion and seal the amatol charge against moisture. In loading a bomb through the tail opening, it is apparent that the TNT surround for the nose fuze must be poured in first. A separate melt unit is provided on the ground floor of the amatol mixing house to supply molten TNT for the purpose of casting TNT surrounds. The following operations are performed incident to loading a bomb with amatol by the casting method:

1. Remove nose plug and tail cap.

2. Inspect bomb interior and repaint if necessary.

3. Remove all grease from bomb and threads.

4. Insert fuze seat liner in nose of bomb sealing threads with animal glue.

5. Gauge fuze seat liner and insert nose plug.

6. Place bomb in loading rack. Insert auxiliary booster with special tool.

The bomb is now ready for TNT bottom pour to surround the nose fuze seat liner; the depth of this pour is shown on the loading drawings. TNT prepared in accordance with specifications is poured into the bomb to a depth somewhat above the joint between the fuze seat liner and auxiliary booster in accordance with the loading drawing, and allowed to cool. After the crust is formed, it is cut down with a brass rod every half hour, taking care not to disturb the core that forms around the auxiliary booster. When the molten charge becomes almost stiff, smooth off the surface with a rod by submerging any crust or chips and allow to set.

Amatol prepared in accordance with preceding paragraphs is drawn into a cooling tub and agitated with a paddle to cool it to a temperature of between 80 C and 85 C. (82 C or 179.6 F is recommended.) The molten amatol is then transferred into pouring buckets and poured into the bomb cavity to a depth as shown on the loading drawing. In loading smaller bombs, a funnel is used to avoid splashing. After the required charge is placed in the bombs, they are transferred to a cooling room where the crust is broken down and cut back in the manner described for TNT. When the amatol charge has become quite stiff and the molten central core has reduced to approximately 4½ inches in diameter, the TNT surround is poured as shown on the loading drawing.

If a tail auxiliary booster is required, it is inserted just prior to this pour and held in place with a special tool. In this case, the breaking down of the TNT crusts is done around this tool, taking care not to disturb the auxiliary booster until the charge around it has cooled. The booster cavity may be formed or drilled at the discretion of the contractor. In either case, a riser must be used for the last pour to eliminate cavitation due to shrinkage. The forming operations usually require the addition of two or three increments of molten TNT and several special tools are required. Complete instructions for forming of drilling operations may be obtained from the Chief of Ordnance.

After drilling or forming the booster cavity, threads should be thoroughly cleaned and freed from all explosive and foreign material. If chemical cleaner is used, no material other than acetone should be used. Care must be taken to prevent the acetone from soaking into the charge. Final assembly of the bomb should be completed as specified by the respective drawings.

Steps should be taken to reduce the waste of amatol scrap to the absolute minimum. Such scrap as is obtained from the cooling tubs and pouring pails can be utilized by puddling it into hot molten bomb castings while thin and friable scrap may be placed into the amatol mixing kettle after the TNT has been introduced and before the charge of ammonium nitrate is added so that remelt is obtained. In this latter instance, the granulation of the scrap should not exceed in size the clearance between the moving and stationary paddles of the amatol mixing kettle.

Density determination, selection of samples, and examination of the explosive charge by means of a split bomb will be carried out in the manner prescribed for TNT. The specific gravity of 50/50 amatol should not be less than 1.50.

Extrusion Method of Loading 80/20 Amatol. 80/20 amatol is a mixture of 80 percent ammonium nitrate and 20 perecent TNT. This material is not fluid enough to use the casting method and has to be handled by the extrusion method. The ammonium nitrate used for this work is prepared in the same manner as that for 50/50 amatol. From this point, the procedure changes for the 80/20 mixture. The ammoniun nitrate is first placed in the amatol mixing kettle and heated to approximately 95 C. The proper proportion of TNT is then added in the liquid state and the mixing continued for at least 15 minutes or until the entire mass has become plastic and of uniform composition. The mixed 80/20 is then transferred to the hopper of the extrusion machine. The hopper of this machine will hold approximately 250 pounds which is sufficient to load 16 155-mm shells. The hopper is steam heated so that the material is maintained in the plastic condition throughout the process. From the hopper, the material is fed into the shell by means of a steel screw operated inside of a steel tube. The shell is first placed on the carriage of the extrusion machine and allowed to run forward so that the end of the screw is within 2 to 4 inches of the base of the shell. At this point, a second trip action disengages the screw so that the shell can be removed from the carriage. A counter weight placed on the carriage of 200 pounds to 300 pounds maintains a steady pressure against the extruding amatol and thus solidifies the charge within the shell.

A number of difficulties arose during World War I in connection with the loading of 80/20 amatol. These difficulties were due to the type of ammonium nitrate which was furnished. If the ammonium nitrate is of fine granulation, low densities will be obtained due to insufficiency of the TNT to fill in the spaces between the crystals. If the crystals are too large, liquid TNT leaks from the extruder and also causes low density. For 2 years, Picatinny Arsenal investigated the loading of 80/20 amatol for the purpose of determining

the type of ammonium nitrate which should be used. The work on granulation has been completed and with a proper control of granulation, no difficulty is encountered with obtaining satisfactory density of the charge. The ammonium nitrate intended for use in the manufacture of 80/20 amatol is listed under specification 50-11-59 as "Class B." The granulations specified are those of commercial grade of ammonium nitrate used in the manufacture of dynamite and no increase in cost should arise.

Shells and bombs loaded with 80/20 amatol are topped off with TNT surround. Density determination, selection of samples, and examination of the explosive by means of a split will be carried out in the manner prescribed for TNT. The specific gravity of 80/20 amatol will be not less than 1.38.

TRIMONITE.

Trimonite is a mixture of 88 percent picric acid and 12 percent alphanitronaphthalene. This material is loaded by the casting method and is handled in the same manner as TNT. At the time of casting, the charge resembles 50/50 amatol more than it does TNT, due to the fact that all of the picric acid has not melted and is in suspension in the liquid. The casting temperature of trimonite is from 95 C to 105 C. Trimonite has practically the same explosive properties as 50/50 amatol. The cast charge has a density of not less than 1.60. Work at Picatinny Arsenal has shown it to be an excellent explosive for shell and bombs and the numerous tests at Aberdeen Proving Ground have failed to indicate a single item which would militate against its use as a shell and bomb filler. To date, however, it has not come into general use for loading high-explosive ammunition.

EXPLOSIVE D.

General. Explosive D (ammonium picrate) is supplied to loading plants in the form of finely divided crystals packed in paper lined wooden boxes. It varies in color from canary yellow to reddish brown. It does not melt on heating, but explodes when heated to a temperature of about 300 C. The only method of loading is to press it into the projectile cavity until the proper density is obtained. Ammonium picrate can react with metals to form metallic picrates but when dry, this action is almost negligible. Wet ammonium picrate reacts slowly, especially with copper or lead, to form picrates which are particularly sensitive and dangerous. Each projectile is carefully inspected before loading and interiors must be clean and well coated with black acid-proof paint, which has thoroughly dried, before loading. Explosive D is used as a bursting charge for armor-piercing projectiles on account of its insensitiveness to shock, which permits the projectile to penetrate the armor without exploding. It will absorb moisture from damp atmosphere and should be stored in dry magazines.

The Pressing Process. Projectiles are loaded with explosive D behind barricades with hydraulic equipment. The shell must be placed centrally under the ram of the press in order to make certain that the ram does not strike the side walls of the shell. The weight of the shell must not rest on the false ogive, armor-piercing cap, or windshield while pressing the charge, but must be supported at a point on the shell wall immediately forward of the bourrelet. This supporting ring must be machined of special steel to very close tolerance in order to prevent the projectiles from sticking in the support.

Explosive D is pressed into shell in increments of various sizes. Starting in the nose of the shell a small amount of explosive D is pressed with a ram of small diameter. The ram is then removed and a larger amount of explosive D added and pressed with a ram of larger diameter. As the height of the pressed charge rises, the diameter of the shell cavity (which is usually cone shaped) increases, and this allows an increase in the diameter of the ram used as well as an increase in each successive increment of explosive. When the cylindrical portion of the shell cavity is reached, the rammer diameter and explosive increment have reached their maximum size and remain constant until the shell is filled to the required height. Pressures required to obtain the desired density may vary from 7,000 to 20,000 pounds per square inch of pressing area of the ram, depending on numerous factors described in the following paragraphs. Pressure per square inch under the ram will be computed as follows:

$$\frac{P \times A}{A_1} = \text{Pounds per square inch under ram}$$

P = Pounds pressure per square inch in press cylinder (dial pressure)

A = Area of press cylinder in square inches

A_1 = Area of ram pressing surface in square inches

Experiments with all shapes of rams show that a flat ram is best. The diameter of the rammer face must be carefully determined. A properly designed ram reduces the danger of the operation by allowing excess explosive D not pressed by the ram to have free escape around the sides. This also produces more uniform densities; a larger ram gives high densities on the sides, a smaller ram gives high densities in the center. When loading is properly carried out, the major portion of the explosive is held firmly under the ram while the excess is given free escape around the sides without undergoing any compression. Relative motion of the particles of explosive D which are held firmly is negligible and the explosive D which escapes is still in proper condition for incorporation in the next increment. If, however, the clearance is too small (clearance area less than 16 percent of the cross section of the cavity, or ram not centrally located in the cavity), the escaping material will be compressed before it gets clear;

and will not be in satisfactory condition for repressing. It will also be noted that unless rams of small diameter are not made long enough, some explosive D may be compressed by the enlarged upper portion of the rammer shaft.

The amount of explosive for each increment and the size of ram and estimated pressure for each have been recorded from actual loading records and may be obtained from Picatinny Arsenal for a large number of projectiles of various sizes. Where records are not available, the rule for determining the size of the increment is that the height of the increment after pressing should not exceed the diameter of the ram by more than 25 percent. The diameter of the ram should be approximately 88 percent of the diameter of the cavity at the increment level after pressing. The pressure required to obtain the specified density varies with the granulation of the explosive and must be determined by actual test. Coarser grained explosive D is relatively easy to press to the required density while a fine, light, fluffy material is very hard to press. Granulation of the explosive is now controlled by current specifications that allow not more than 20 percent to pass a No. 100 U. S. standard sieve.

Setting Up the Loading Procedure. In preparation for the loading of shell, it is necessary to load the point increment into a projectile in strict accordance with the procedure so far outlined, and carefully note the following:

1. Weight of explosive.

2. Diameter of ram.

3. Maximum pressure applied and length of time the maximum pressure was held before releasing. It may be necessary to vary this time from 3 to 30 seconds.

4. Diameter of shell cavity at top of pressed increment.

5. Total length of pressed increment.

6. Condition of explosive remaining unpressed.

7. Centering of ram with respect to shell cavity.

CAUTION: Care must be exercised during experimental work to prevent the ram striking the shell cavity walls, especially on the first increment where the cavity diameter is small and tapers to a point.

The shell is removed from the press and the increment is carefully dug out by cutting it away from the side walls of the shell with a chisel-pointed brass rod. All large pieces are saved for determination of specific gravity by the mercury method. If uncompressed explosive is found in the bottom of the shell cavity, one or more of the following may be the cause and must be corrected: increment too large; ram too large in diameter; not enough pressure applied; or a combination of several causes. A properly pressed first increment will hold its shape to the point of the cavity and when care is used in cutting, a sample for density calculation can be obtained from the cavity point.

Corrections are made, and the above is repeated on several shells until a satisfactory increment of uniform density is obtained. The specific gravity of all samples is carefully recorded and charts to show a cross section of the cavity for each sample shell. Like procedure is followed for all increments. When satisfactory results are obtained, this procedure then becomes standard practice for loading the particular increment involved.

After samples are removed for density determination of the increment under development, samples are further cut out until the shell is entirely unloaded and the density of all previously loaded increments is checked. All results are checked against the points noted above, and a chart is prepared for each experimental shell. If the specific gravity runs higher than required, the possibility of increasing the size of the increment should be investigated with a view of reducing operating costs and increasing production. The use of more pressure than is required to obtain specified density should also be avoided. The foregoing procedure is continued until a standard practice has been developed for each increment. The height to which the last increment is pressed will be determined by a study of the drawing of the shell being loaded. Excess explosive to be cut away to allow seating of the base plug should be kept to a minimum.

The first projectile is loaded in accordance with the procedure so far outlined. Samples are taken for specific gravity in accordance with U. S. Army Specifications 50-15-1A. If the procedure has been correctly developed, the specific gravity throughout the charge should be satisfactory. If not, such corrections to the loading procedure as may be necessary are made. A good plan is to select several shells at intervals from the first day's production and remove samples for specific gravity to check operations. These results should definitely prove the quality of loading and if satisfactory, production should proceed. The shells used for all previous tests should be thoroughly cleaned, and the interiors should be recoated as required by the drawing.

Specific Gravity. The selection of sample shells for determination of specific gravity of the explosive charge should be made by the inspector in accordance with U. S. Army Specification 50-15-1A. The number selected varies from 1 for each 50 to 1 for each 1,000 shells loaded, depending upon the type and caliber of the shell. Samples for the determination of the specific gravity of the charge should be taken from each increment of loading and should be sufficient in number to represent all parts of the charge. The samples may be taken with a core drill or by using a metal bar of nonsparking material with a chisel point. Each of the samples of explosive should be cut to approximately a ¾-inch cube, and the specific gravity should be

determined on each sample by the mercury displacement method, as follows:

Clean the samples so as to leave no sharp corners, and weigh accurately on a laboratory balance. For determining the displacement, use an apparatus consisting of a glass beaker with ground top, a piece of glass of sufficient size to completely cover the top of the beaker, and a semihard rubber perforated plate, pierced at each corner with sharp pointed pins so that about ½ inch of pin protrudes from each side. Fill the beaker with clean mercury. Insert the rubber plate, and level off the mercury by pressing down with a flat glass until it is even with the top of the beaker. Place the sample beneath the prongs of the rubber plate, and level the mercury as before. Catch the excess mercury in a clean bowl. Weigh the mercury displaced, and calculate the specific gravity of the sample as follows:

$$\text{Specific gravity} = \frac{13.54\,W}{W_1}$$

W = weight of sample in grams

W_1 = weight of mercury displaced in grams.

For armor-piercing projectiles the specific gravity should not be less than 1.45 in all parts of the charge. For projectiles other than armor-piercing, the specific gravity should not be less than 1.35 in all parts of the charge.

After the last increment has been passed, the shell is removed to a convenient location for assembly of the base plug, fuze, and base cover. Excess explosive is removed from the projectile by means of a cutter having a contour the same as the inner face of the base plug. The amount of explosive removed should be such that the void between the inner face of the base plug and the explosive charge would not exceed 0.125 inch. Loose explosive left by the cutter should be removed by an approved vacuum unit and the threads thoroughly cleaned of all explosive dust. Waste explosives from drilling and thread cleaning operations must not be reclaimed but should be destroyed in accordance with safety regulations.

Base plugs are not interchangeable and both shell and plug must be cold stamped with a serial number before removing the plug to insure reassembly in the shell to which it belongs. NOTE: All base plugs and base fuzes are equipped with left-hand threads. The inner face of the plug must be coated with black acidproof paint and dusted lightly with flake graphite when thoroughly dry. A small quantity of the specified lubricant is applied to the threads of the base plug and the base plug is screwed into the projectile until it is properly seated flush with the base of the projectile. The plug is unscrewed one or two turns, and paraffin is poured through the fuze hole until it completely fills the void between the explosive charge and inner face of the plug.

The base plug is immediately tightened in the projectile and the paraffin is allowed to solidify.

A cutter having a contour which conforms to the contour of the fuze body is inserted through the fuze hole and the fuze cavity is drilled in the explosive charge. NOTE: Where a fuze seat liner is required, it must be inserted prior to final assembly of the base plug. The depth of this cavity should be such that when the fuze is assembled any void existing between the fuze and face of the explosive charge will not exceed 0.025 inch. All surfaces of the fuze coming in contact with the explosive must be coated with black acidproof paint. All loose explosives are removed from fuze cavity and fuze hole threads. A small quantity of approved lubricant is applied to the fuze threads before assembly. The fuze is screwed firmly in place until it seats flush with the base plug. In most cases the fuze comes to a positive stop against a shoulder in the fuze hole. Where a positive stop is not provided, the fuze is held in place with a locking pin. Wrench hole filling plugs are inserted as required. The calking groove is thoroughly cleaned and the base cover is assembled complete with lead disc. The projectiles are painted and marked as required by specifications and drawings.

In view of the fact that proper loading of projectiles depends absolutely on the size of the increment, the size of the ram, the pressure applied, and the granulation of the explosive, it can readily be seen that the explosive operators must follow instructions to the letter. The rate of application of the pressure and the time of holding the pressure on the explosive must be uniform, as disregard of these points alone can give a variation in density greater than allowed by specifications.

The foregoing information is to be used only as a guide where applicable to the various loading activities. Specific operations will be governed by the drawings, specifications, operation studies, standard practice sheets, and other instructions issued by the Chief of Ordnance.

TETRYL.

Tetryl has been recently adopted as a standard filler for small high-explosive shells. It is first blended with a small percentage of graphite or stearic acid and then pressed into pellet form (dry). These pellets are made to fit the inside diameter of the cavity to be filled. The correct number of these pellets are placed in the shell cavity and reconsolidated by a final pressing operation. Operators are always protected by a shield or barricade when pressing tetryl. To date, tetryl has been used principally as a filler for 20-mm and 37-mm high-explosive shells.

TETRYTOL.

This is a mixture of tetryl and molten TNT. As some of the tetryl goes into solution, the mixture can be successfully cast with as high

as 70 percent tetryl and 30 percent TNT by weight. The principal use and advantage of tetrytol is in loading boosters and bursters by the casting method. These items were previously loaded with dry tetryl which was pressed into pellets and then reconsolidated by pressing into the burster or booster casing. The mixture is agitated until ready for casting to prevent separation or settling. The use of tetrytol loaded boosters and bursters has been approved except where the loaded item is plunged into or surrounded by a hot bursting charge, such as (auxiliary boosters in demolition bombs) where a remelt of the tetrytol might occur. The advantages of casting over pellet reconsolidation, especially in long burster tubes, is tremendous from a standpoint of simplicity of operations, safety, and cost of equipment.

PENTOLITE.

This is a mixture of PETN and TNT. The 50/50 mixture results in a considerable increase in the brisance of TNT as measured by the rate of detonation. It is more sensitive to friction and shock than TNT and where booster cavities have to be drilled, a mixture of 10 percent PETN and 90 percent TNT is used for the booster surround.

50/50 pentolite is supplied in the dry state packed in the same manner as TNT. It is loaded by the casting method, 5-pound steam pressure on a steam jacketed open kettle being sufficient to melt the dry material. As the dry material melts, it must be constantly agitated to keep the PETN in suspension, since only a small portion of it goes into solution with the TNT. This agitation, usually by air driven propellers or hand paddles, must be continued until the material is cast into the ammunition being loaded.

The stability of pentolite is not as good as straight TNT. Long periods of storage under high temperature may result in a separation of the material and the loss of its greatest effectiveness as an explosive of high brisance. Every effort must be made to store it in a cool, dry place.

SECTION IV.

CHEMICAL WARFARE AGENTS

Chapter 1

Chemical Agents

INTRODUCTION.

General. Chemical agents are many times referred to as the weapons which can "shoot around corners," due to their ability to filter through small crevices and to settle in all recesses, thus seeking out their victims. A great many people feel that, because of this, chemical agents are too brutal and too inhuman to be used by a civilized nation. The facts from World War I prove otherwise. Of the 275,000 American casualties, more than one-fourth were caused by gas. Of the gas casualties, only about 2 percent died. Of those caused by other weapons nearly 25 percent died. In other words, the man wounded by gas had about twelve times the chance to live, in comparison with his fellow soldier suffering from the effects of the traditional weapon. Those who have opposed gas weapons on the basis of inhumanity have long since been halted by the facts.

No form of warfare is humane, for war is the negation of humanity. Before one concludes that gas warfare is too horrible for a civilized people to tolerate, he should compare gas casualties with the injuries resulting from high explosives, bullets, and bayonets. He should think of the torture that comes to the man who has been bayonetted, before death releases him, or to the man whose face has been shattered by a bullet which destroys eyes, nose, and jaw, yet fails to bring the release of death. He should also remember that most gas casualties can be avoided. Proper gas discipline and use of protective equipment can reduce to a very small percentage the number of men put out of action by chemical agents. A man in the open is helpless against the missile weapons, there is nothing he can do to avoid injury by bullets, flying pieces of metal, or shock of explosion. He can and should avoid injury by gas.

History. The idea of using chemical agents in warfare was not conceived as many believe in the days of World War I. History shows that the seed of chemical warfare has always been present in military thought. Only a proper combination of conditions was required to bring it to a vigorous life. The required conditions did not exist until the latter part of the nineteenth century, and the proper combination was not reached until the First World War.

The earliest recorded use of chemicals in military operations was at the siege of Plataea, 428 B.C., where the Spartans used gas as an offensive weapon against the Athenians. Wood, saturated with pitch

and sulfur, was burned under the walls of the city in order to create choking and poisonous fumes to assist the assault in subduing the defenders. This operation would have been most successful if a sudden rainstorm had not put out the fire. A similar operation at the siege of Delium, 5 years later, was a complete success.

Ancient chronicles report that about the year 360 B.C., the Greeks used suffocating and incendiary mixtures formed of various chemical substances easily ignited and hard to extinguish. They consisted of pitch, sulfur, tow, and resinous wood chips. This compound was put into pots which were thrown burning from besieged towns upon the "tortoise," the shelter under which the besiegers attempted to approach the walls. Later, incendiary arrows and other incendiary devices shot from catapaults came into use.

Greek fire was perhaps the most famous of all of the early means of chemical warfare. This compound was a powerful incendiary which produced suffocating fumes. Early writers state that it would ignite when brought in contact with the water and float and burn on the surface of the sea. The exact composition of Greek fire is not known. The process for its manufacture was kept a close secret for several hundred years. It must, however, have contained rosin, pitch, sulfur, naphtha or petroleum, quicklime, and perhaps also saltpeter. It was discharged from tubes in the bows of the ships.

At the siege of Petra, in the days of the Roman Empire, the Persians used vases filled with a fire compound of sulfur, asphalt, and naphtha. These were thrown into the city by mangonels, a military engine for hurling rocks and javelins. When they broke, the compound burst into flames which could not be extinguished and which gave off choking gases.

Smoke was successfully used in a river crossing by Charles XII of Sweden in 1701. Under cover of a thick cloud produced by burning damp straw, Charles was able to cross the Dvina and take position in the face of superior forces before the enemy learned what was happening.

During the siege of Sebastopol, 1855, Admiral Lord Dundonald submitted a plan for the use of sulfur gas for the reduction of the Russian forts. The English government admitted the plan was feasible, but would not permit putting it into execution. The use of sulfur was suggested at the siege of Charleston in the Civil War.

As a matter of fact, modern chemical warfare might just as well have started during the War Between the States in 1862 as during the World War in 1915. Only the failure of the War Department to grasp the golden opportunity offered prevented this. Not only was a practical scheme for using gas recommended, but the suggestion incorporated the use of the very gas that the Germans used so successfully at Ypres over 50 years later.

During World War I, the first gas attack of any consequence was the famous gas cloud attack at Ypres in April 1915. The chemical agent used in this attack was chlorine and the casualties numbered about 5,000 men. Although the element of surprise was perfect, the Germans failed to make the gains that were possible because they failed to realize the effect the attack had on the Allied morale.

Chlorine was followed by phosgene, also developed by the Germans, in an attack which took place on December 11, 1915. This attack was not successful because the Allies were ready for it.

Mustard followed next in line, being introduced by the Germans near Ypres on July 12 1917. This marked the first use of a chemical agent which would linger in one place for a great length of time and thus render that area unfit for use.

From this period in the First World War, chemical agents were developed in rapid succession by all nations, and new agents are still being experimented with and adopted for use today.

GENERAL.

Most people, when the words "chemical warfare" are mentioned, immediately think "poison gas." As a matter of fact, in the Chemical Warfare Service the agents are often referred to as "gases." The term "poison gas," however, is a misnomer. Most of the chemical combat substances are liquids and solids which are disseminated in the air by various methods. Some are contained in shells, or bombs, which explode and throw the liquid or solid agent into the air in drops or in fine particles. Some solids, are vaporized by heat within a container and pass into the air as a smoke. Others, generally liquids, are carried in tanks upon airplanes and released into the air to fall to the ground as droplets or as a fine mist. A few, those which enter readily into the gaseous state, can be released directly from cylinders, merely by opening a valve, and form a dense cloud which is carried by the wind.

Definition. Whether these materials are called chemical agents, combat chemicals, or poison gases, the terms all refer to any substance, useful in warfare, which by its ordinary and direct chemical action, produces either a powerful physiological effect, a screening smoke, or an incendiary action. Note the words "by direct chemical action." The active agent itself creates casualties directly. TNT, picric acid, smokeless powder, are all chemicals but they are useful in war because they propel shell fragments or bullets by their explosion. They exert their chemical effect indirectly and so are not spoken of as chemical agents.

Requirements. Of the many thousands of poisonous substances known to the chemist, the number that are important as agents of chemical warfare may almost be counted on the fingers. One may

point out very good reasons why there are so few effective combat chemicals. Not only must the warfare agent have irritant or toxic properties sufficient to irritate or cause casualties in extremely low concentrations, but it must also possess suitable physical characteristics and chemical properties, and meet rigid economic standards.

To find a material that will combine all requirements is practically impossible. There are 10 requirements which the ideal war gas must possess. To meet the ideal specifications, a chemical agent for our armed services must be:

1. Effective in small concentrations.

2. Unreactive, and not so easily neutralized or destroyed.

3. Easily manufactured in large quantities.

4. Composed of raw materials easily procurable on the North American continent or in the Western Hemisphere.

5. Cheap.

6. Easy to transport, compressible to a liquid.

7. Stable in storage and stable against shock of explosion.

8. Heavier than air.

9. Effective against all parts of the body; combination of lung, eye, skin, and nose irritant.

10. Odorless, tasteless, colorless; not easily detected.

All of these requirements obviously cannot be found in one chemical, they represent the ideal. Certain of them are essential. Every agent must combine at least the first five.

It is because of the necessity of meeting these requirements, especially the first three, that we have so few agents from which to choose.

Obviously, any agent to be useful must be effective in extremely small concentrations. It is necessary to understand how extremely small the concentrations of the really powerful chemical agents can be and still be effective. For example, one of the tear gases has a pronounced irritant effect at a concentration of eight ten-thousandths of an ounce (0.0008 ounces) in a thousand cubic feet of air. More than an ounce of this material can be held in the hand. Suppose an ounce of it is divided into 10,000 small parts. Then eight of these parts are put into a box 10 feet high, 10 feet long, 10 feet wide. This almost infinitely small quantity of tear gas inside the large box would cause much discomfort if one were in it for 3 minutes. It can thus be understood that by small concentrations of chemical agents, almost infinitesimal quantities are referred to quantities which can be disseminated in the air with little difficulty.

The most poisonous chemical that exists is valueless in warfare unless it can be manufactured quickly and in sufficient quantity. The chemical that is effective, cheap, and easily manufactured, is of little use if protection against it is easily obtained. Consequently, one quality of the ideal chemical agent is that it must not combine readily with other substances, so that it cannot be easily destroyed or removed. An unreactive chemical is sought, since the unreactive chemicals are more likely to pass through a gas mask without being filtered out.

Stability is important. The ideal agent should be stable in storage and also stable against the shock of explosion. Even if the agent were otherwise effective, it would not be used if it had a tendency to break down into its elements after storage for several weeks or several months, or if it would break down when fired in a shell. Lack of stability was one of the reasons why the very poisonous hydrogen cyanide, or hydrocyanic acid, proved to be a poor war gas. It was unstable in storage and also unstable to shock. Since the last war, suitable means have been found of stabilizing this poisonous material.

The chemical selected must not be too corrosive or it will destroy the container and itself. Several agents, which might otherwise be desirable, have to be used in glass-lined shells or containers because of their corrosive nature. The use of special linings or special containers complicates manufacture, is expensive, slows down production.

To be used on the battlefield, a gas must be heavier than air. Gases lighter than air rise and may have no effect on the man on the ground. They dissipate too rapidly. The fact that hydrogen cyanide is just a trifle lighter than air is another reason for its previous failure as a war gas.

An agent that will affect all parts of the body is far more useful than one which will affect only the lungs or the eyes or the skin. That is one reason why mustard gas is such an extremely valuable war material. If a man breathes it, he will become a dangerous casualty through the effects of the gas on his lungs. A very small amount in the surrounding atmosphere causes a powerful irritation on the eyes over a period of time. If a gas mask is worn, a man's lungs and eyes are protected. However, mustard gas is still effective even against a man wearing the gas mask, since it also affects the skin and causes serious burns.

Finally, the ideal war gas should be odorless, tasteless, and colorless. It would thus get in its deadly effect without the victim knowing it and making an effort to protect himself. No such toxic gas exists, with the possible exception of carbon monoxide which has neither color, odor, nor taste. However, although carbon monoxide is extremely poisonous, cheap, easily available, and stable; it is lighter than air and can not be compressed to liquid form. No method has ever been found that would permit its use in large quantities on the battlefield as a poison gas. Carbon monoxide, nevertheless, does cause deaths in battle because some of it is formed in every explosion. When

a high-explosive bomb or shell bursts in an inclosed space, men who escape the effects of the blast sometimes die from the effects of the carbon monoxide produced. This, however, is an incidental effect and carbon monoxide is not considered as an agent of chemical warfare.

Classification. Chemical agents are classified in various ways, depending upon who is doing the classifying, and in what phase of the subject the classifier is interested.

To obtain the color marking used on chemical ammunition, the classification according to tactical use is taken as the basis. The painting of chemical ammunition is as follows:

The round is painted a blue-grey base color to denote a chemical filler.

Then the round is marked with a band or bands and stencil, the color of which is based on the type of agent used as the filler.

Casualty agents	Green
Irritating or harassing agents	Red
Screening smoke agents	Yellow
Incendiary agents	Purple

The number of bands on a round depends upon the persistency of the agent used as a filler. By persistency is meant the time after dispersal of the agent that it will be effective in the area in which it was released. Agents which remain effective for over 10 minutes are termed persistent, while those which remain effective for less than 10 minutes are termed nonpersistent. Persistent agents are marked with two bands and nonpersistent agents are marked with one band.

According to their physiological effects, chemical agents are classified as lung irritants, vesicants, lacrimators, irritant smokes (sternutators), screening smokes, and incendiaries.

The lung irritants are those agents which when breathed cause irritation and inflammation of the bronchial tubes and lungs.

The vesicants are those agents readily absorbed through both the exterior and the interior parts of the human body, resulting in the production of inflammation, blisters, and general destruction of tissue.

Lacrimators are those agents which cause a copious flow of tears, and intense, although temporary, eye pain.

Irritant smokes, also called sternutators, are those agents which cause sneezing, coughing, lacrimation, headache, followed by nausea and temporary physical disability.

Screening smokes are those agents which when burned, hydrolyzed, or atomized, produce a dense obscuring smoke in air.

Incendiaries are those agents which are used primarily for setting fire to materiel.

SYMBOL	NAME	CLASS	BANDS COLOR	LOADING	ODOR	TACTICAL CLASS	PHYSIOLOGICAL EFFECT
H	MUSTARD	Gas	2 Green		Garlic Horseradish Mustard		Burns skin or membrane
L	LEWISITE	Gas	2 Green		Geraniums		Irritates nasal passages. Later skin burns, poison.
ED	ETHYLDI-CHLORARSINE	Gas	2 Green		Biting Stinging		Causes blisters, sores
PS	CHLORPICRIN NITROCHLOROFORM	Gas	2 Green	+ CG + CN	Flypaper Anise		Causes severe coughing, crying, lung edema
DP	DIPHOSGENE TRICHLOROMETHYL CHLOROFORMATE	Gas	2 Green		Musty Hay Green Corn Ensilage		Causes coughing, breathing hurts, eyes water, tears
CG	PHOSGENE CARBONYL CHLORIDE	Gas	1 Green		Musty Hay Green Corn Ensilage		Irritates lungs
CL	CHLORINE	Gas	1 Green	+ PS + CG	Highly Pungent		Intense immediate choking
CN *(CNS)	CHLORACETO-PHENONE	Gas (Solution)	1 Red (2 Red)		Apple blossoms		Makes eyes smart, shut tightly, tears flow. Temporary.
BBC	BROMBENZYL-CYANIDE	Gas	2 Red		Sour fruit		Eyes smart, shut, tears flow. Effect lasts some time.
DM	ADAMSITE DIPHENYLAMINE CHLORARSINE	Gas	1 Red	(H-CN)	Coal Smoke		Causes sneezing, sick depressed feeling
PD	DIPHENYL-CHLORARSINE	Gas	1 Red		Shoe Polish		Causes sneezing, sick depressed feeling
HC	HC MIXTURE	Smoke	1 Yellow		Sharp-acrid		Harmless
FS	SULFUR TRIOXIDE IN CHLOROSULFONIC ACID	Smoke	1 Yellow		Burning matches		Liquid burns skin if allowed to remain
FM	TITANIUM TETRACHLORIDE	Smoke	1 Yellow		Acrid		Harmless
WP	WHITE PHOSPHORUS	Smoke	1 Yellow		Burning matches		Burning pieces adhere to skin, clothing
†TH	THERMIT (THERMITE) IRON OXIDE AND ALUMINUM POWDER	Incendiary	1 Purple		Odorless		5000 degree F. heat ignites materials

* CNS, A SOLUTION OF CN IN CHLOROFORM AND CHLORPICRIN, FREQUENTLY USED FOR SHELL FILLING

† THE FILLING OF A MAGNESIUM BOMB WHICH SERVES TO IGNITE THE METAL MAGNESIUM CASING

RA PD 27686

Explanatory Chart—Chemical Ammunition

PROTECTION	FIRST AID	COLOR & STATE		PERSISTENCE	TACTICAL USES
		LOADED	RELEASED		
	Remove clothing. Wash affected parts of body with soapy water. Irrigate eyes with 2% sodium bicarbonate solution	HEAVY DARK, OILY LIQUID	Liquid slowly evaporates	Open - 1 day Woods - 1 week to all winter	To neutralize areas Counter-battery Attack on Personnel
	Apply 3 to 5% solution hydrogen peroxide to skin; wash with soap and water. Irrigate eyes with water or 2% sodium bicarbonate solution	HEAVY DARK, OILY LIQUID	Liquid slowly evaporates	Open - 1 day Woods - 1 week	Similar to Mustard
	Apply 3 to 5% solution hydrogen peroxide to skin; wash with soap and water. Irrigate eyes with water or 2% sodium bicarbonate solution	CLEAR OILY LIQUID	Evaporates at medium rate.	1 hour	Counter-battery Preparation fire Harassing fire
	Wash eyes, keep quiet and warm. Do not rub eyes	YELLOW OILY LIQUID	Evaporates like water.	Open 6 hours Woods - 12 hours	Harassing and casualty fire
	Keep quiet and warm Give coffee as a stimulant	COLORLESS LIQUID	Evaporates like water.	30 minutes	Harassing and casualty fire
	Keep quiet and warm Give coffee as a stimulant	COLORLESS LIQUID	Colorless gas	10 to 30 minutes	Surprise attacks, projectiles Gas cloud release For quick physical effect
	Keep quiet and warm Coffee as stimulant	YELLOW LIQUID	Yellow-green gas	10 minutes	Surprise attacks (cloud)
	Wash eyes with water or boric acid. Do not rub or bandage. Wash skin with 4% Na_2SO_3 in 60% Alcohol Solution	WHITE CRYSTALLINE POWDER	Cloud of small, solid particles	10 minutes	Training Mob control CNS used in counter-battery to force mask wear
	Wash eyes with boric acid Do not bandage	DARK BROWN OILY LIQUID	Slowly evaporates	Several days (weeks in winter)	To neutralize areas Counter-battery
	Remove to pure air and keep quiet. Breathe small amounts of chlorine	YELLOW-GREEN GRANULAR SOLID	Yellow smoke	10 minutes	Gas Cloud Attacks Mob control.
	Remove to pure air, keep quiet Sniff chlorine from bleaching powder bottle	WHITE CRYSTALLINE SOLID	Vapor or fine smoke	Summer 10 minutes	Harassing fire
NONE NEEDED	Produces no effect requiring treatment	GREY SOLID	White to grey smoke	While burning	To screen small operations in own lines and for training purposes
	Wash with Soda solution	CLEAR TO BROWN LIQUID	Dense white smoke	5 - 10 minutes	Airplane spray for screen on broad front.
NONE NEEDED	Produces no effect requiring treatment	YELLOWISH TO BROWN LIQUID	White smoke	10 minutes	Screening operations
NONE AVAILABLE	Wash with Copper Sulphate solution or immerse in water	PALE YELLOW SOLID	Burns to white smoke in air	10 minutes	To screen advancing troops Cause incendiary effects, losses Harass enemy observers.
COVER WITH EARTH, SAND	Treat for burn	METALLIC POWDER	White-hot metal	5 minutes	Destruction of Material.

RA PD 27691

Explanatory Chart—Chemical Ammunition

VESICANTS.

Mustard, H, Dichlorethylsulfide, $S(CH_2CH_2)_2Cl_2$.

Properties. When pure, mustard is a transparent, amber, oily liquid of 1.27 specific gravity, which boils with slight decomposition at 433.6 F, yielding a vapor 5.5 times as heavy as air.

Odor. It is almost odorless in ordinary field concentrations and in strong concentrations resembles horseradish or mustard.

Persistency. Because of its low volatility, mustard gas is very persistent in the field, varying from 1 day in the open and 1 week in the woods in summer, to several weeks both in the open and in the woods in winter. Its great persistency is the principal limitation on its use, as it cannot be used on the tactical offensive where friendly troops have to traverse or occupy the infected ground. However, by the same token, mustard is particularly adapted for use in the tactical defensive, to prevent the occupation by hostile troops of ground evacuated on withdrawal.

Physiological effect. Mustard is classified as a vesicant gas. At first it acts as a cell irritant, and finally as a cell poison. The first symptoms of mustard-gas poisoning appear in from 4 to 6 hours, but a latent period up to 24 hours may occur. The length of the latent period depends upon the concentration of the gas. The higher the concentration the shorter the interval of time between the exposure to the gas and the first symptoms arising as a result of mustard-gas poisoning.

The physiological action of mustard gas may be classified as local and general. The local action results in conjunctivitis or inflammation of the eyes; erythema of the skin, which may be followed by blistering or ulceration and inflammatory reaction of the nose, throat, trachea, and bronchii.

It is of interest that racial susceptibility to toxic action of mustard gas exists; the Caucasian is more susceptible than the Negro. There is also an individual susceptibility to the toxic action of mustard gas, particularly of the skin, and also of the respiratory tract.

Protection. Complete protective clothing plus the gas mask are required for protection against mustard gas. A discussion of the protective equipment follows at the end of the discussion of chemical agents.

First aid. To be effective, treatment must begin within a few minutes after exposure. Immediate prophylaxis is effective only up to 5 minutes after liquid contamination. It is of little value after exposure to vapor because, in this form, most of the agent has penetrated the skin before the person reports for treatment.

Contaminated clothing must be removed quickly, using proper precautions (mask, gas proof gloves, apron, protective ointment) to protect the attendant. Clothes must be placed in a covered metal container until decontaminated.

Great care must be taken in the removal of mustard from the skin; otherwise the agent will merely be spread. The steps are as follows:

1. Gently apply dry pads to absorb any mustard remaining on the skin.

2. Swab the area repeatedly with Protective Ointment M4, wiping the ointment off thoroughly after each application.

3. Scrub the contaminated area with soap and water.

4. Pat the area dry with a towel. *Do not rub.*

5. Burn or bury the materials contaminated during the procedure.

In the event that Protective Ointment M4 is not available, step 2, above, may be done with the application of sponges dampened with kerosene, CARBON TETRACHLORIDE, or alcohol. When following this procedure, the sponges should be damp with the solvent; if dripping wet, they may dissolve the agent and spread it as they run over the skin.

The eyes should be irrigated with a 2 percent solution of sodium bicarbonate. The solution should be run directly into the eyes with a rubber tube from an enema can or similar container. Petrolatum on the edges of the eyelids will prevent their sticking together.

If it is likely that mustard has entered the mouth or nose, the mouth and nasal passages should be rinsed and the throat gargled repeatedly with 2 percent solution of sodium bicarbonate. The patient should be kept quiet and warm to guard against bronchitis and bronchopneumonia.

If nausea and vomiting indicate that contaminated materials have been swallowed, the stomach should be washed out by repeated drinking of warm 2 percent solution of sodium bicarbonate. This will induce vomiting and wash out the irritant.

After decontamination, all persons with eye, nose, and throat burns, and with extensive skin burns should be hospitalized. Skin burns must be treated surgically as any severe extensive burn.

Lewisite, Chlorvinyldichlorarsine, $CHClCH\text{-}AsCl_2$.

Properties. Lewisite is an oily, colorless to light amber liquid, of 1.88 specific gravity, which boils at 374 F, yielding a dense vapor 7.1 times heavier than air. The freezing point of lewisite is 0 F.

Odor. Its odor faintly resembles that of geraniums.

Persistency. Lewisite is slightly less persistent than mustard. Under average conditions, in summer, it persists for 24 hours in the open, and from 2 to 3 days in woods. In winter it may last for a week or more.

Physiological effect. Physiologically, lewisite acts similarly to mustard gas and in addition is a systemic poison when absorbed into the body through the skin or lungs. It may, therefore, be classed as primarily a vesicant, secondarily a toxic lung injurant, and tertiarily a systemic poison when absorbed in the tissues. Lewisite is then both a general and local toxic of great strength. The effects of lewisite are visible much more quickly than those of mustard.

Protection. Complete protective clothing plus the gas mask are required for protection against lewisite. A discussion of the protective equipment follows the discussion of chemical agents.

First aid. Treatment must begin within 1 minute after exposure to liquid lewisite to be really effective. Contaminated clothing must be quickly removed with precautions to protect the attendant, and treatment should be started while the clothing is being removed.

The contaminated areas should be swabbed immediately and repeatedly with hydrogen peroxide. Solutions with 10 or even 20 percent available oxygen are best, but are somewhat unstable. The ordinary 2 percent solution available in drug stores will suffice. If hydrogen peroxide is not available, a solution of 10 percent sodium hydroxide in a 30 percent solution of glycerin in water, alternating with 70 percent alcohol, is the second choice. The glycerin protects the skin from the hydroxide. If no glycerin is available, 5 percent sodium hydroxide in water may be used. Lacking all of these, the solvents and technique described for liquid mustard must be used. Following treatment, the skin should be washed with soap and water and patted dry. All contaminated cloths or sponges must be burned or buried.

It is important that patients contaminated with lewisite come immediately under medical treatment. The doctor must open the blisters as soon as possible to prevent further absorption of arsenic. In opening the blisters, he must be careful to prevent infection and must remember that the blister fluid itself is capable of producing burns.

Liquid lewisite in the eyes is an emergency. The eyes must be rinsed immediately with 2 percent hydrogen peroxide. If that is not available, they must be irrigated with 2 percent solution of sodium bicarbonate. Delay may result in blindness.

Ethyldichlorarsine, ED, Ethyldichlorarsine, C_2H_5-$AsCl_2$.

Properties. Ethyldichlorarsine is a clear, somewhat oily liquid of 1.7 specific gravity, which boils at 312 F, yielding a vapor 6.5 times denser than air.

Odor. It has a stinging odor similar to that of pepper in the nose.

Persistency. Ethyldichlorarsine has a persistency of about 1 hour.

Physiological effect. Although ethyldichlorarsine is a fairly powerful sternutator and vesicant agent, its primary action on the body is as a lung injurant. Its first effect in low concentrations is a respiratory irritant. The effect upon the eyes and upper respiratory tract is evanescent, while that upon the lower respiratory tract leads to membranous tracheitis and pulmonary congestion, edema, and pneumonia. Arsenic is absorbed rapidly and leads to systemic poisoning, characterized by lowered temperature, toxic symptoms, anesthesia, and depression.

On short exposure (less than 5 minutes), ethyldichlorarsine is not a particularly efficient irritant for the human skin. On exposure greater than 5 minutes, however, positive burns appear which increase in severity with length of exposure. On the basis of rapidity of action, extent of rubefaction, swelling and edema, and time of healing, ethyldichlorarsine is about two-thirds as effective as mustard gas, but for vesication it is only about one-sixth as effective.

Protection. Complete protective clothing plus the gas mask are required for protection against ethyldichlorarsine. A discussion of the protective equipment follows at the end of the discussion of chemical agents.

First Aid. Immediate measures are the same as for lewisite. Nose irritation may be relieved by inhaling dilute chlorine from a small amount of bleaching powder in a wide-mouthed bottle or can. Repeated drinking of warm 2 percent sodium bicarbonate solution should be used for vomiting.

LUNG IRRITANTS.

Chlorpicrin, PS, Nitrochloroform, CCl_3NO_2.

Properties. Chlorpicrin is a colorless, oily liquid of 1.66 specific gravity, which boils at 231.5 F, giving off a vapor 5.6 times heavier than air.

Odor. Its odor is rather sweetish in nature resembling that of fly-paper or anise.

Persistency. Chlorpicrin has a persistency of about 6 hours in the open and 12 hours in the woods.

Physiological effect. It is a lethal compound which acts primarily as a lung injurant. In toxicity, it is intermediate between chlorine and phosgene.

In addition to its lung injurant effects, chlorpicrin is also a strong lacrimator, and has the additional advantage of being capable of penetrating gas mask canisters that are resistant to ordinary acid gases, such as chlorine and phosgene. The injurious effects of chlorpicrin also extend to the stomach and intestines, causing nausea, vomiting, colic, and diarrhea. These conditions are difficult to combat in the field and often persist for weeks so that even slight cases of chlorpicrin gassing frequently involves large casualty losses.

Protection. The service gas mask will provide adequate protection against this type of chemical agent.

First aid. Absolute rest and warmth are essential. The patient should be removed immediately to a pure atmosphere and made to lie down, kept at absolute rest, and kept warm with blankets. A person affected by lung irritants should always be moved on a litter or stretcher. He must never be allowed to walk. A light stimulant or hot coffee may be given. A glass of milk or cream, if available, will give marked relief from pharyngeal irritation, and the patient should be hospitalized. In cases of splashes of liquid on the skin, it should be washed off at once with alcoholic sodium sulphite, in order to prevent ulcerations. Skin scratches and abrasions exposed to chlorpicrin fumes or liquid develop a high degree of inflammation and easily become infected.

Diphosgene, DP, Trichlormethyl-chloroformate, $ClCOOC{\cdot}Cl_3$.

Properties. Diphosgene is an oily liquid of specific gravity 1.65. It boils at 260.6 F, giving a dense whitish vapor 6.9 times heavier than air.

Odor. It has an acrid odor which strongly resembles that of musty hay, green corn, or ensilage.

Persistency. Diphosgene has a relatively short persistency of about 30 minutes on open ground.

Physiological effect. The toxicity of diphosgene is about the same as that of phosgene. In fact, it is probable that the toxicity of diphosgene is not a specific property of that compound, but is derived from the phosgene molecules into which it decomposes in the tissues of the body.

Diphosgene is somewhat lacrimatory and thus causes watering of the eyes, as well as coughing, and occasional vomiting.

Protection. The service gas mask will provide adequate protection against this type of chemical agent.

First aid. The first aid for this type of chemical agent is the same as that given for chlorpicrin above.

Phosgene, CG, Carbonyl Chloride, $COCl_2$.

Properties. At ordinary temperatures and pressure, phosgene is a colorless gas which condenses at 46.7 F, to a colorless liquid of 1.38 specific gravity. Above 46.7 F, phosgene immediately evaporates, although at a slower rate than chlorine, and gives off a transparent vapor, 3.5 times heavier than air.

Odor. It has an odor which strongly resembles that of musty hay, green corn, or ensilage.

Persistency. Because phosgene is a gas it is nonpersistent, remaining in the open for up to 10 minutes. It will, however, remain in low protected areas for as long as 30 minutes.

Physiological effect. The toxicity of phosgene is over 10 times that of chlorine. In high concentrations, which are often met in battle, one or two breaths may be fatal in a few hours. Phosgene appears to exert its physiological and toxic effects chiefly through the medium of its hydrolysis products, hydrochloric acid, and carbon dioxide. Its effects upon the upper air passages of the body, where moisture is relatively small, is therefore comparatively slight. With prolonged breathing, however, sufficient phosgene is decomposed in the bronchi and trachea to produce marked inflammation and corrosion. These effects reach their maximum in the alveoli where the air is saturated with water.

Unlike chlorine, phosgene produces but slight irritation of the sensory nerves in the upper air passages, so the men exposed to this gas are likely to inhale it more deeply than they would to equivalent concentrations of chlorine or other directly irritant vapors. For this reason, phosgene is very insidious in its action and men gassed with it often have little or no warning symptoms until too late to avoid serious poisoning.

Protection. The service gas mask will provide adequate protection against this type of chemical agent.

First aid. The first aid for this type of chemical agent is the same as that given for chlorpicrin above.

Chlorine, Cl, Chlorine, Cl_2.

Properties. At ordinary temperatures and pressures, chlorine is a greenish-yellow volatile gas. It is readily liquefied by moderate pressure at ordinary temperatures. When liquid, it has a specific gravity of 1.46 and when a gas it is 2.5 times heavier than air.

Odor. Chlorine has a highly pungent odor.

Persistency. Chlorine is a gas, and as such is nonpersistent. It remains at the point of dispersal for a short length of time, up to 10 minutes.

Physiological effect. Chlorine has a very irritating effect upon the membranes of the upper air passages. It causes violent coughing immediately if small amounts are breathed. It can also be lethal on continued exposure to the agent.

Protection. The service gas mask will provide adequate protection against this type of chemical agent.

First aid. The first aid for this type of chemical agent is the same as that given for chlorpicrin above.

LACRIMATORS.

Chloracetophenone, CN, Chloracetophenone, $C_6H_5CO{\cdot}CH_2Cl$.

Properties. When pure, chloracetophenone consists of colorless crystals, of 1.3 specific gravity, which melt at 138 F, and boil at 476 F, yielding a vapor which is 5.2 times as heavy as air.

Odor. The odor of apple blossoms is characteristic of both the solid and the vapor.

Persistency. In the solid form, chloracetophenone is very persistent. However, in the vapor form, as usually released, it has a persistency of about 10 minutes. For this reason, it is classed as nonpersistent.

Physiological effect. Chloracetophenone, being a lacrimator, has the effect of producing a copious flow of tears when breathed. In addition to its lacrimatory effect, chloracetophenone is a decided irritant to the upper respiratory passages. In higher concentrations, it is irritating to the skin, producing a burning and itching sensation especially on the moist parts of the body.

Protection. The service gas mask will provide adequate protection against this type of chemical agent.

First aid. The individual should be removed from the contaminated air and face the wind with the eyes open. If irritation is marked, the eyes may be irrigated with boric acid or a 2 percent solution of sodium bicarbonate. The eyes must not be rubbed or bandaged.

Skin irritation may be treated by sponging with a solution of 4 percent sodium sulfite in 50 percent alcohol. All symptoms usually disappear within 1 hour.

Brombenzylcyanide, BBC, Brombenzylcyanide, $C_6H_5CH{\cdot}BrCN$.

Properties. Brombenzylcyanide is a yellow-white crystalline solid which melts at 77 F into a brownish oily liquid of 1.47 specific gravity, and boils at 437 F, giving off a vapor which is 6.6 times as heavy as air.

Odor. This substance has an odor similar to that of soured fruit.

Persistency. Its persistency in the open is 3 days; in woods, 7 days; and in the ground, from 15 to 30 days.

Physiological effect. Brombenzylcyanide produces a burning sensation of the mucous membranes and severe irritation and lacrimation of the eyes with acute pain in the forehead.

Protection. The service gas mask is adequate protection against this type of chemical agent.

First aid. The first aid for this agent is the same as that given for chloracetophenone above.

STERNUTATORS (IRRITANT SMOKES).

Adamsite, DM, Diphenylaminechlorarsine, $(C_6H_4)_2{\text -}NH{\text -}AsCl$.

Properties. The impure commercial product used in chemical warfare is a dark brownish-green crystalline mass which partially liquefies

at 320 F, but the major portion does not melt until a temperature of 374 F is reached. It has practically no vapor pressure or vapor density, as it distills into the air in the form of minute solid particles.

Odor. Adamsite has an odor which closely resembles that of coal smoke.

Persistency. The persistency of adamsite averages about 5 minutes in the open both in summer and in winter.

Physiological effect. It strongly irritates the eyes and mucous membranes of the nose and throat and causes violent sneezing and coughing. It then produces severe headaches, acute pains and tightness in the chest, and finally nausea and vomiting. The effects last for about 3 hours.

Protection. The service gas mask will provide adequate protection against this type of chemical agent.

First aid. Remove to pure air. Let the patient inhale dilute chlorine from a small amount of bleaching powder in a wide-mouthed bottle or can. Headache may be controlled with 10 to 15 grains of aspirin. There are no after effects and the person recovers within a few hours.

Severely exposed persons must be watched for suicidal tendencies. Continue to reassure them that their symptoms will be of brief duration and are not dangerous.

Diphenylchlorarsine, PD, Diphenylchlorarsine, $(C_6H_5)_2{\text -}AsCl$.

Properties. Diphenylchlorarsine is a white crystalline solid, of 1.4 specific gravity, which melts at 113 F. It boils with decomposition at 720 F. It has practically no vapor pressure or vapor density as it distills into the air in the form of minute solid particles.

Odor. The characteristic odor of diphenylchlorarsine is comparable to that of shoe polish.

Persistency. The persistency of diphenylchlorarsine is about 5 minutes in either summer or winter.

Physiological effect. The irritation begins in the nose, as a tickling sensation, followed by sneezing, with a flow of viscous mucus, similar to that which accompanies a bad cold. The irritation then spreads down into the throat and coughing and choking set in until finally the air passages and the lungs are also affected. Headache, especially in the forehead, increases in intensity until it becomes almost unbearable, and there is a feeling of pressure in the ears and pains in the jaws and teeth. These symptoms are accompanied by an oppressive pain in the chest, shortness of breath, and nausea which soon causes retching and vomiting. The victim has an unsteady gait, a feeling of vertigo, weakness in the legs, and a trembling all over the body.

Protection. The service gas mask will provide adequate protection against this type of chemical agent.

First aid. The first aid for diphenylchlorarsine is the same as that for adamsite given above.

SCREENING SMOKES.

HC Mixture, HC, Hexachlorethane-zinc, $Zn+C_2Cl_6$.

Properties. HC mixture is a combination of zinc dust, hexachlorethane, ammonium perchlorate, and ammonium chloride. When this material is burned, it yields zinc chloride which passes into the air in the form of a grayish-white smoke.

Odor. The odor of the smoke is rather acrid in nature.

Persistency. As the smoke is formed only as long as the particular round is burning, the persistency of the smoke will continue only as long as the burning continues.

Physiological effect. The zinc chloride smoke which is formed is harmless to personnel. Its use being to screen off operations from the enemy.

Protection. As the smoke has no harmful effects there is no protection required against this agent.

First aid. No first aid is needed as far as the smoke is concerned. If burns are produced from the burning agent, they should be treated as for any other burn.

Sulfur Trioxide in Chlorsulfonic Acid, FS, SO_3-SO_3HCl.

Properties. This mixture is a liquid of 1.91 specific gravity, which freeezes at —22 F. On contact with the air, it fumes vigorously and throws off dense white clouds composed of minute droplets of sulfurous, sulfuric, and hydrochloric acids.

Odor. The odor of this mixture is similar to that of burning matches.

Persistency. The persistency of this agent varies from 5 to 10 minutes.

Physiological effect. Although the smoke is harmless, it irritates the skin and throat. Spray in the eyes may cause serious burns.

Protection. Because of the irritation to the nose and throat, and the burns to the eyes, a gas mask is needed to prevent such action.

First aid. This consists of washing with large quantities of water. In the eyes, this should be followed by irrigation with a 2 percent solution of sodium bicarbonate.

Titanium Tetrachloride, FM, Titanium Tetrachloride, $TiCl_4$.

Properties. Titanium tetrachloride is a colorless, highly refractive liquid, of 1.7 specific gravity, which boils at 277 F and solidifies into white crystals at −9 F. It reacts vigorously with the moisture in the air, forming titanic acid hydrate and hydrochloric acid, with the evolution of dense white clouds of acrid smoke.

Odor. The smoke has an acrid odor.

Persistency. The persistency of this agent is approximately 10 minutes.

Physiological effect. On account of its hydrochloric acid content, titanium tetrachloride is acrid, but in ordinary field conditions it is not sufficiently irritating to the respiratory system as to cause coughing or other unpleasant physiological effects. The liquid may cause slight irritation to the skin due to its acidic nature.

Protection. No protection is needed against this agent.

First aid. The first aid for this agent is the same as that given for FS above.

White Phosphorus, WP, Yellow Phosphorus, P.

Properties. White phosphorus is a waxy solid, of 1.8 specific gravity, which melts at 111 F, and boils at 549 F. It is chemically very active and combines readily with oxygen in the air. Upon oxidation, the phosphorus becomes luminous and in a few minutes bursts into vigorous flames that can only be quenched by complete submersion in water.

Odor. The odor of phosphorus is similar to that of burning matches.

Persistency. The persistency of white phosphorus is about 10 minutes.

Physiological effect. While the vapors of white phosphorus are exceedingly toxic, these vapors are so quickly oxidized to phosphorus pentoxide and phosphoric acid as to be harmless to men and animals in ordinary field conditions.

In addition to its smoke value, phosphorus is of tactical importance because of its burning effect upon both personnel and material. In contact with the body, phosphorus produces burns that are slow and difficult to heal; the firing of phosphorus against personnel has a physiological value that greatly increases its tactical effectiveness. Against material, however, the incendiary effect of phosphorus is limited, as it only ignites readily combustible materials, so that here it is inferior to thermite and other primarily incendiary materials.

Protection. No protection is required against the smoke derived from white phosphorus. No satisfactory material has been found which will give protection against the burning particles of the material and still afford freedom of movement and comfort to the wearer under working conditions.

First aid. Keep the burn wet with water or wet cloths. This will stop the phosphorus from burning. Then apply large amounts of copper sulphate solution. Continue this treatment for three minutes. Remove the phosphorus particles (copper plated) by washing, or with forceps and treat the injury like an ordinary burn.

INCENDIARIES.

Thermite, TH, Thermite, 2Al-3FeO.

Properties. Thermite is an intimate mixture of iron oxide and finely powdered aluminum. It is in the form of a dark-gray granular mass. When ignited, it burns with great rapidity and the evolution of extreme heat, the iron oxide being reduced to boiling molten iron.

Odor. This material is odorless.

Persistency. The average thermite has a persistency of about 5 minutes.

Physiological effect. There is no physiological effect derived from thermite other than that of burns from the hot metal. If any of this material gets on skin or clothing, it will cause severe burns.

Protection. No protection is needed for personnel other than that of cover from the burning particles.

First aid. Burns received from the hot metal may be treated the same as ordinary burns.

PROTECTIVE EQUIPMENT.

Protective Clothing. Protective clothing is designed to protect the body against vesicant agents. There are two requirements which govern the kind of protective clothing needed. One requirement is to provide protection for certain personnel engaged in filling operations who might encounter large pools of the liquid or be subjected to sprays of the agent from broken pipes and vessels in case of accidents. The other is to provide protection for personnel required to handle contaminated equipment, engage in decontamination operations, or be protected from vapor or from airplane spray attacks. In the first consideration, a complete impermeable suit is required. It is not recommended for any use except in potentially dangerous situations where liquid mustard gas or lewisite in large quantities may likely be encountered. In the second situation, permeable protective clothing provides ample protection for all cases where vapor, absorbed mustard gas, or light spray of liquid gas is encountered.

Impermeable clothing. Impermeable suits are made of coated materials which will not allow liquid vesicants or vapors to pass through them. Since there is no circulation of air, the wearer perspires excessively and can wear this covering for only a relatively short time because of exhaustion. There is no satisfactory method of neutralizing liquid mustard gas on the garment, and accordingly it must be destroyed when excessively contaminated. A suit of impermeable clothing consists of a 1-piece working garment made of impermeable material with an attached hood of the same material. Under this suit, protective permeable underclothing and socks are worn. The foot covering consists of treated shoes over which the legs of the impermeable suit are buckled tightly. Boots of a type of rubber highly resistant to mustard gas or lewisite penetration can be substituted for the shoes, provided the trousers are pulled on over the boot leg. Highly resistant rubber gloves and a gas mask are likewise worn.

Permeable clothing. The permeable type of clothing consists of garments treated in such a manner that they afford reasonably safe protection against vesicant chemical agents in the form of vapor and small drops. The ordinary field uniform can be treated to provide considerable protection, yet permit much comfort and serviceability. However, specially designed garments add greater protection because of the necessity of covering completely all parts of the skin. Each suit includes one pair of socks, one pair of gloves, one pair of drawers, one undershirt, one hood and one 1-piece protective suit (coveralls). For protection of the feet, the wearer treats his footgear with impregnite issued for that purpose. It is sometimes advisable to include a nontreated set of underwear with the above treated outfit because of the allergy of some skins to the treated clothing. Protection of the hands is afforded by the chemically treated cotton gloves which may be supplemented by outer chemically resistant rubber gloves. For protection of the face, eyes, and lungs, a mask must also be worn.

Gas mask. The gas mask protects the wearer's eyes and respiratory tract from the chemical agents.

The principle of operation of the gas mask is based on air filtration. Air is drawn into the mask when the individual inhales, the mask being so constructed that the air must pass first through a canister containing a filtration system. This comprises a mechanical filter to prevent the entrance of smoke or dust, and a filter of charcoal and soda lime to absorb and neutralize toxic and irritating gases and vapors. After being purified, the air is drawn into the face piece, and after being inhaled and exhaled is expelled from the mask through an outlet valve. Gas masks, as issued, will give full protection against lung irritants, irritant smokes, and lacrimators in concentrations likely to be encountered. They will not protect against gases encountered in industry such as carbon monoxide and ammonia gas.

The service gas mask is the one that is commonly issued for the use of inspectors in the field. This type of mask will afford protection against all agents likely to be encountered under field conditions. A tube of antidim compound is included in the carrier, and if applied in a very thin film to both sides of the eyepiece, will assist in preventing fogging of moisture in the mask and from rain. The canister is carried in a carrier under the left arm and is connected to the face piece by a noncollapsible rubber hose. It must be remembered that, to be of any use, the gas mask must be correctly adjusted to the wearer. Any leaks around the face piece will prevent the mask from performing its proper function of preventing the entrance of the agent into the nasal passages.

FURTHER REFERENCES: O.O. 7224, Ordnance Safety Manual; FM 21-40, Defense Against Chemical Attack; Pamphlet No. 2, Chemical Warfare School, Edgewood Arsenal, Md.; Protection Against Gas, U.S. O.C.D., Washington, D. C.; Chemicals in War, Prentiss; Gas Warfare, Waitt.

SECTION V.
SMALL ARMS AND TRENCH WARFARE

Chapter 1
Small-arms Ammunition

GENERAL.

Small arms refers to those weapons normally accompanying foot troops (infantry). They include rifles, automatic rifles, pistols, and machine guns up to cal. .60 (0.60 inches diameter of bore) and also shotguns. Small-arms ammunition is defined as "amunition fired in weapons whose bore is 0.60 inches or less in diameter." In ordnance, small-arms ammunition is restricted to mean ammunition for those small arms used in military service. These are:

1. Cal. .50 machine guns.

2. Cal. .30 carbines, rifles, semiautomatic rifles, automatic rifles, and machine guns.

3. Cal. .22 pistols, rifles, and machine guns (for gallery practice).

4. Shotguns of 12-gage.

5. Cal. .45 automatic pistols, revolvers, and submachine guns.

6. Subcaliber tubes and adapters for artillery weapons which use ammunition of similar size and type.

Caliber and Gage. The caliber of a weapon is the diameter of the bore of the weapon between opposite lands, and in the instance of small arms, is expressed in inches unless millimeters are specifically mentioned. For example, cal. .30, means that the diameter of the bore of the weapon is 0.30 inches.

The gage of a shotgun refers to the number of lead balls of the diameter of the bore required to weigh 1 pound. For example, the diameter of the bore of a 12-gage shotgun is 0.785 inches, and it takes 12 lead balls of this diameter to weigh 1 pound.

Classification. Dependent on its purpose, small-arms ammunition is classified as follows:

Ball. This type is effective against personnel or light materiel targets.

Armor-piercing. This type has a bullet containing a hardened steel core. It is intended for use against armored aircraft and vehicles, concrete shelters, and other bullet resisting targets.

Tracer. This type has a bullet containing a chemical composition which burns in flight. It is used for observation of fire, for incendiary purposes, and for signaling.

Incendiary. This type has a bullet containing a chemical composition. It is used to start fires.

Blank. This type contains no bullet. It is used for simulated fire, for signaling, and for salutes.

SECTION VII.
BOMBS FOR AIRCRAFT

Chapter 1
Introduction

DEVELOPMENT.

Improvised Bombs. The development of bombs depends on the previous development of aircraft. In the early part of the eighteenth century, long before man thought of using bombs, he perceived the playful idea of sending gaily colored bags of paper, buoyed up by hot air, into the sky. The military significance of this idea was not realized until 1794 in the battle of Maubeuge. The Austrians were surprised to see, hovering above the French lines, huge paper bags having two baskets. One basket contained hotcoal or charcoal to emit hot gases so as to keep the balloon aloft. In the other basket sat an observer to keep watch on all of the Austrian movements far beyond the range of vision of the average man.

In 1849 in a battle between the Austrians and Venetians, the Austrians found that the range of their batteries was too short to reach the city of Venice. When the wind was in the proper direction, blowing toward the city of Venice, the Austrians attached small bombs with time fuzes to paper balloons. The balloons were capable of lifting the bombs to altitudes of 30 feet, and drifted into the city. When well inside the city, the time fuzes exploded the bombs. Some bombs exploded in the canals of Venice. The material and physical damage which resulted was slight; however, the psychological effects were great.

In 1899, at the Hague Conference, an agreement was reached to prohibit the throwing of projectiles from balloons. In 1903, the Wright brothers invented the airplane. In 1907, the restrictions of the Hague Conference were removed.

By 1910, military authorities of all the major powers had begun experimenting with airplanes. The plane was regarded, however, as a more efficient means for gaining information in the field, and not so important for dropping explosives in enemy territory. The earliest recorded use of bombs dropped from planes was made in 1911 by the Italians in Tripoli. The Italians desired to drive the Arabs and Berbers from the strategic harbor of Tripoli. These early bombs were makeshift equipment dropped by hand over the side of a plane.

During the first few weeks of World War I, planes were used for observation purposes only. These planes had no guns nor bomb sights. It was customary during these few weeks for hostile aviators meeting over the lines to salute each other and then proceed to their respective missions. At the end of the first 3 months, however, all belligerents had organized squadrons to drop bombs. These bombs were crude artillery shells, such as 3-inch and 75-mm, equipped with fins and fuze. The planes had no sighting apparatus and no bomb racks. Bombers operated as free lancers, and accuracy depended on luck and judgment. A bomb which struck about ¼ mile from its target was considered fair aim.

By the end of World War I, bomb squadrons were of great importance, due to the vast improvement in planes, including speed, load capacity, bomb sights, and bomb racks. Also, there was a great improvement in bombs. Special purpose bombs such as incendiary, demolition, and fragmentation appeared. The size of the demolition bomb increased. During the war, the United States government manufactured large quantities of bombs. However, the United States forces in France were limited to bombs of British and French design. No bombs of American manufacture reached the front in time. Demolition bombs used at that time were 45-pound, 122-pound, and 230-pound. The fragmentation bombs used was the 25-pound British Cooper bomb.

Demolition Bombs. The demolition bomb as known today was developed during World War I. The demolition bomb as its name signifies was designed to produce a demolishing effect by producing a blast and mining result. It, therefore, carried the greatest percentage of filler possible.

The first demolition bombs made by the United States were the Mk. I series. These followed the streamlined tear-drop design of the French demolition bombs, and were manufactured in 25-, 50- and 100-pound sizes. None of these bombs saw service in World War I. The construction consisted of welding separate steel sections together by means of circumferential and longitudinal welds. The bombs contained approximately 50-percent explosive filler. The fins were known as conical type fins. The fins were four in number, and extended over the rear one-third of the case. They were made from light sheet steel. The rear tip was welded to a cone which covered the fuze and completed the streamline contour of the case. The front tips were held to the bomb case by screws threaded into lugs which were welded on the case. A tail fuze of the arming pin type was employed. These bombs had many disadvantages, several of which can be listed as follows:

The body welds provided weak spots where the case might split open upon impact before proper penetration and detonation could be obtained.

The fins were not stable enough to produce satisfactory flight.

The fins had to be removed to fuze the bomb.

The fuze was armed immediately after withdrawal of the arming wire, and therefore could function while still in the bomb bay of the plane.

The small nose opening did not lend itself well to rapid and economical filling with explosive filler.

The method of manufacture of the bomb cases was long and costly.

In an attempt to remedy the faults of the Mk. I Bombs, a series of modifications and new bombs were developed. Some of the modifications included the elimination of the 25- and 50-pound bombs because they were too small for effective blast. Larger size bombs such as the 300-, 600-, 1,100-, and 2,000-pound demolition bombs were introduced. Nose and tail fuzes were included to decrease the chance of duds, and the fin assembly although still conical was made much more stable and permitted the tail fuze to be assembled without being removed. These modifications took place over a period of years, and later, some of the smaller weight demolition bombs had the tail assembly changed from conical to box type. All had a new nose fuze and tail fuze with appropriate adapter boosters included where necessary in a modernization program so as to incorporate some of the advantages in these bombs which the new M-series bombs at that time included. These bombs were known as the Mk. IMI, Mk. IMII, Mk. IMIII, Mk. IMIV, Mk. IMV, Mk. III, and Mk. IIIMI. The modification depended on the weight of the bombs. For example, the MI modification in the 100-pound bomb did not correspond to the MI modification in the 2,000-pound bomb.

A Mk. II series of bombs was later designed and tested at Aberdeen Proving Ground. This was known as a thick case bomb. These bombs were similar in construction to the 100-pound Mk. IMI Bomb in every respect, except that the cases were made of extremely heavy material, very much like our semiarmor-piercing bombs of today. The case was designed heavy enough to withstand proper penetration of any target so as to determine whether the use of flying fragments or blast had the greater effect. As a result of the test, this series was never standardized, for it was found that extremely heavy cases were not needed to withstand impact. Blast effect was found to be the significant factor in demolition bombs.

Later still, a Mk. III-series of bombs known as a thin case bomb was developed. Again the shape and construction was similar to the 100-pound Mk. IMI Bombs. The filler percentage was increased, however, to 55 percent. This series of bombs was found to be satisfactory and was included in the modernization program previously mentioned.

The forerunner of the M-series was the 2,000-pound Mk. I Bomb. About 1921, when the demolition bombs were undergoing development, it was decided that experiments with larger bombs were necessary. The result was the design and manufacture of test bombs 2,000-, 3,000-, and 4,000-pound bombs. The tests, as conducted, showed that the effects of 2,000- and 3,000-pound bombs were not sufficiently different to warrant the additional weight. As for the 4,000-pound

bomb, it was decided at that time that the destructive forces of the 4,000-pound bomb were too great for any man-made target, and a plane carrying two 2,000-pound bombs had twice as great a chance of hitting the target. The 4,000-pound bomb was, therefore, discarded. The final result was the 2,000-pound Mk. I Demolition Bomb.

The design of this bomb was revolutionary in so far as the shape of body and fin assembly were concerned. The 2,000-pound bomb was cylindrical in shape and allowed in later manufacture a 1-piece construction with no welding, casting, or other difficult procedure of manufacture. The fin was box shape in construction. This shape of bomb case and fin assembly, and the construction of bomb body was the forerunner of the M-series of demolition bombs and AN-M series of GP bombs.

TYPES OF BOMBS AND FILLERS.

Demolition. This group is composed of the following:

G.P. (general purpose) . . Filled with Amatol, TNT, or composition B
L.C. (light case bombs) . . . . Filled with amatol
S.A.P. (semiarmor-piercing) . . . . Filled with amatol
A.P. (armor-piercing) . . . . Filled with explosive D
D.B. (depth bomb) . . . . Filled with torpex or TNT

Fragmentation. Filled with TNT.

Chemical (Including Incendiary). Filled with HS, WP, or incendiary composition.

Practice.

Demolition. Filled with sand and black powder spotting charge.

Fragmentation. Filled with black powder spotting charge or pyrotechnic composition.

Drill and Gage. Inert or no filler.

PAINTING AND STENCILING.

General. Bombs are painted for prevention of rust, as a means for identification, and for camouflage. All bombs, except chemical, are painted olive drab, lusterless, base color, with black stencil for camouflage purposes.

Demolition. For identification purposes, GP, LC, AP, and depth bombs have three yellow bands to indicate high-explosive filler. One band, 1 inch wide, is located at each end of the bomb body, and one, one-fourth inch wide, is at the center of gravity.

Fragmentation. Fragmentation bombs have nose and tail caps painted yellow to indicate high-explosive filler.

Practice. Practice bombs, simulating GP bombs, have three blue bands instead of the yellow bands, whereas practice bombs, simulating fragmentation bombs, have the ends painted blue instead of yellow to indicate practice bomb filler. All practice bombs except the 100-pound M38A2 have "EMPTY" stenciled longitudinally in at least four places. When the spotting charge is added "EMPTY" is painted out. The 100-pound M38A2 is shipped separately from the spotting charge which is always added in the field. When practice bombs, which contain no spotting charge, are intended to be dropped in training, the fins and rear portions will be painted black.

Drill. Drill bombs have three black bands in place of yellow to indicate inert filler.

Chemical. Chemical bombs are painted with the same color scheme as other chemical ammunition. The base color of chemical bombs is blue gray with bands and stencil color to indicate type of filler and persistency of filler.

Marking. The following information is stenciled on the bomb body:

1. *Type.* "G.P.," "A.P.," "SAP.," "DEPTH," "FRAG.," "CHEM.," or "PRACTICE" whichever applies.

2. *Weight and mark or model of bomb.* For example, 100-pound, AN-M30.

3. *Kind of filler (if filled).* Example, "TNT," "AM 50-50," "CN GAS," "WP SMOKE," etc.

4. The word "EMPTY" is stenciled on unloaded bombs containing no explosive. At the time of loading, "EMPTY" is painted out with paint of the same color as that on the bomb body. The exception to this statement is the 100-pound M38A2, as previously explained.

5. Lot number of loaded bomb.

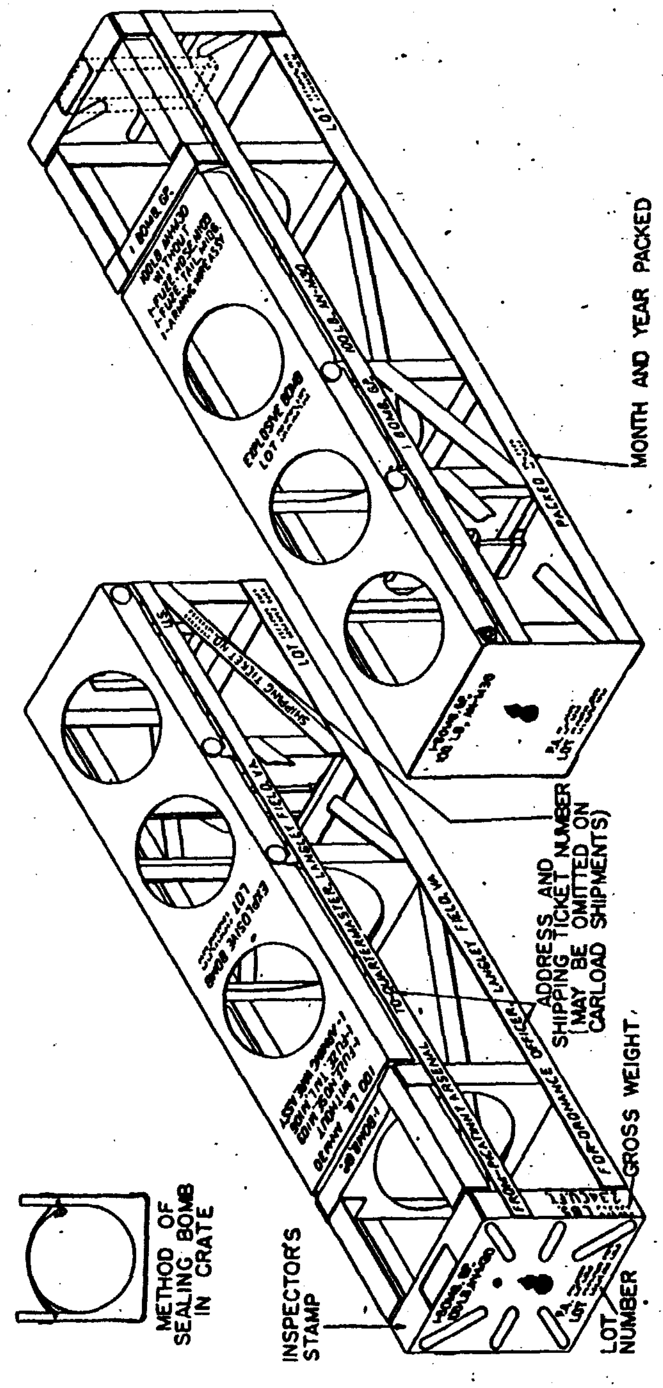
6. Initials of loading plant, and date loaded.

PACKING AND SHIPPING.

For the purpose of packing and shipping in general, bombs can be divided into three weights: under 100 pounds, 100 pounds, and over 100 pounds.

Bombs under 100 pounds in weight including fragmentation, chemical (incendiary) and practice fragmentation bombs are usually packed and shipped in clusters completely assembled, one cluster per metal-lined wooden box. The number of bombs in the cluster depends on the shape and size of the bombs and the size of cluster.

GP bombs weighing 100 pounds are packed and shipped in metal crates with fin attached and nose and tail shipping plugs threaded into the bomb body so as to close the nose and tail openings. Chemical bombs weighing 100 pounds are packed unfuzed, without burster, in wooden boxes.



RA PSD 413A

Figure 222 — Packing Crate for 100-pound G.P. Bomb

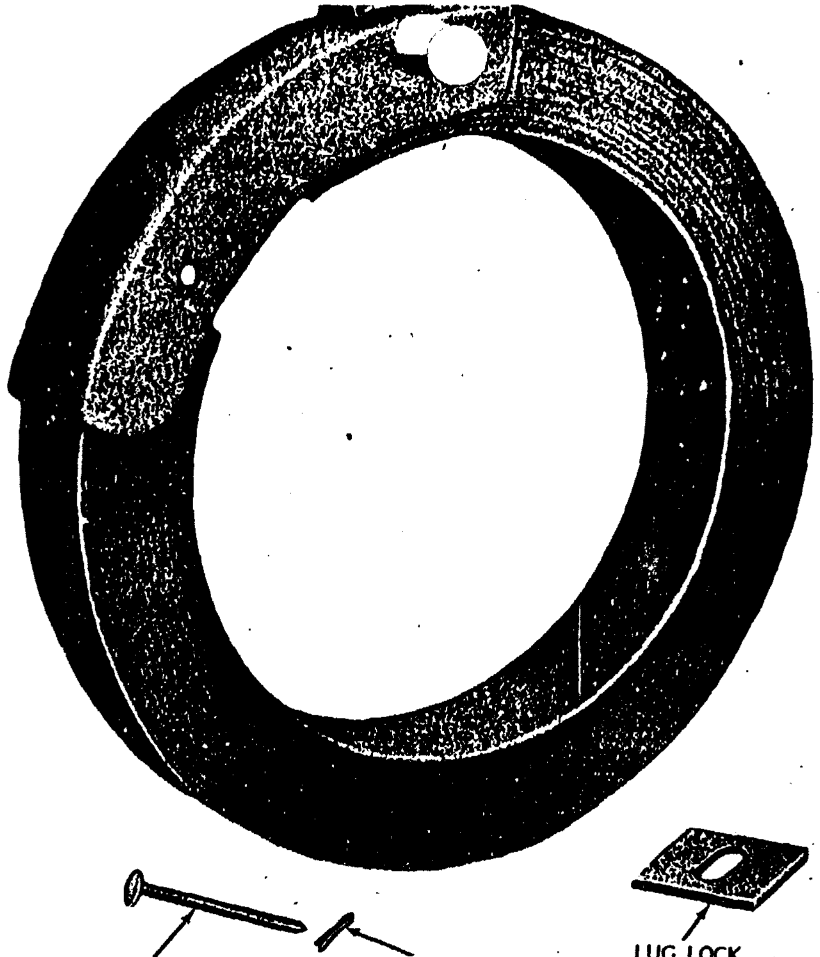


Figure 223 — Paper Shipping Band

Bombs weighing over 100 pounds such as GP, AP, SAP, LC, and depth bombs are packed in two parts. One part consists of the bomb body with shipping plugs to protect the nose and tail openings, if such are present. Shipping bands are channeled to fit over the suspension lugs around the circumference of the bomb. These bombs are provided with slots to attach slings, hooks, or any other means of handling. The shipping band protects the suspension lugs from damage and provides tracks for rolling the bomb on hard surfaces. Shipping bands are made of metal or, more recently, of layers of paper glued together.

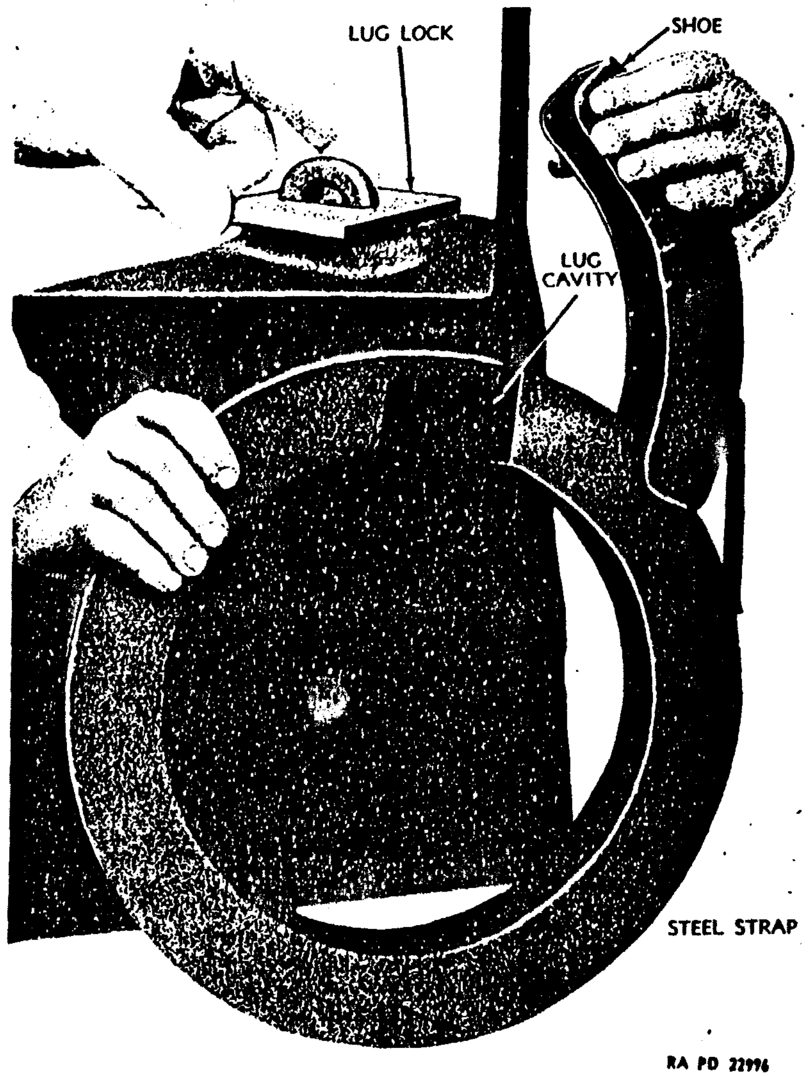
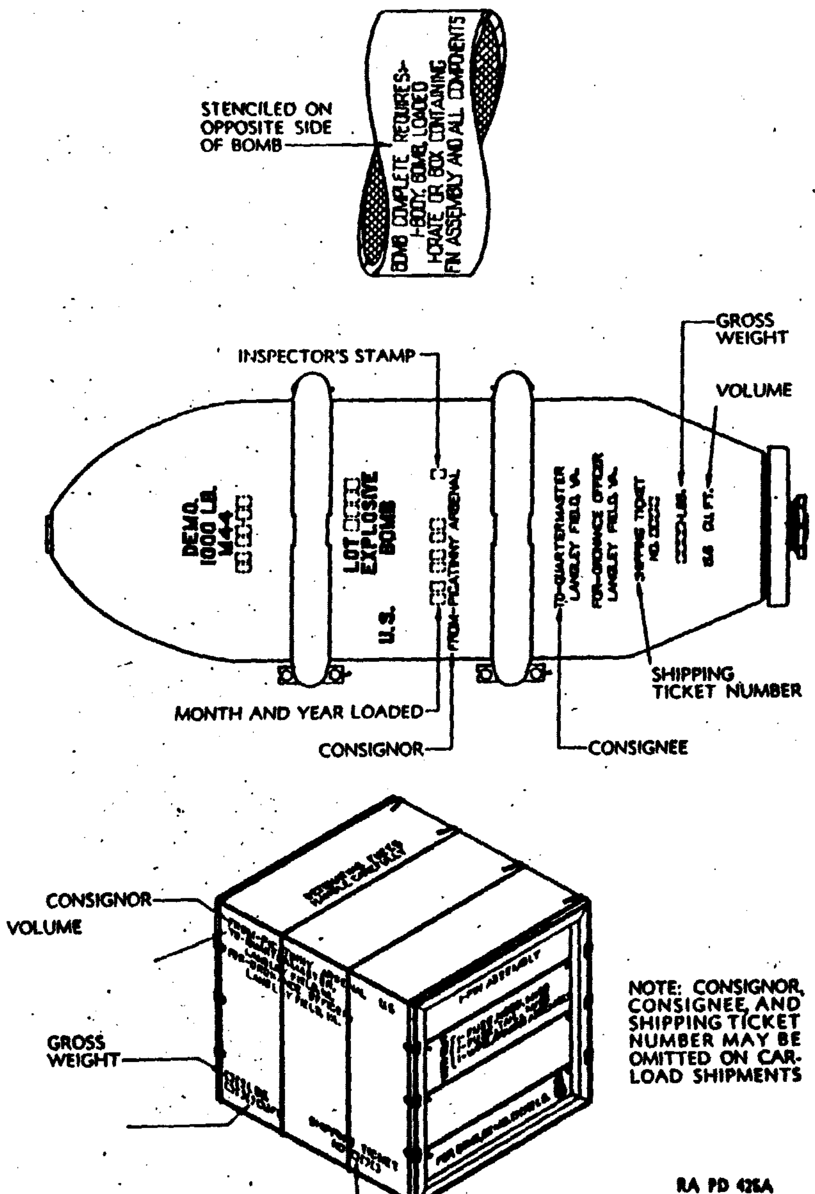


Figure 224 — Paper Shipping Band Showing Lug Cavity



RA PD 426A

Figure 225 — BOMB, Demolition, 1,000-pound—as Shipped

The second unit of the packing of bombs over 100 pounds is the fin assembly which is packed in a metal crate. Metal is used for all AN bombs because Navy regulations will not permit wood aboard ships. The nose and tail fuze assembly and arming wire assembly will be shipped separately in bulk.

Components of unassembled rounds are never assembled until ready for use and when assembled, fuzes are threaded in handtight, never with the use of tools.

ARMING WIRE.

An arming wire is usually used with each complete round of bomb to provide a means whereby the fuzes are restrained from arming until such time as the bomb is released. At release, retention of the arming wire in the release mechanism of the plane arms the fuzes, while release of the arming wire with the bomb permits it to be dropped safe in friendly territory if the necessity arises.

Standard arming wire is of hard-drawn brass wire provided in either of two diameters, 0.036 and 0.064 inch, dependent upon the model of the bomb. To facilitate use, a swivel loop is attached at one end, or near the middle of the arming wire, dependent upon whether the bomb is fitted with one or two fuzes. A safety clip (phosphor bronze Fahnestock connector No. 3) is required for each type of arming vane type fuze. To aid in installing the smaller bombs in vertical bomb racks, if used, a serrated wire paper clip is furnished. At present, the tendency is to issue the arming wire, swivel loops, safety clips, and serrated wire paper clips unassembled in bulk. Standard arming wire assemblies have been found to be too short in some cases when alternate fuzes are used in bombs. Components in bulk consist of a 40-pound coil (approx. 3,300 ft) of 0.064-inch arming wire, 100 swivel loops, 100 Fahnestock connectors, and arming wire ferrules as required. The ferrules are included to aid in attaching swivel loops.

When assembled to the fuze, the protruding end of the arming wire should be adjusted to a length of approximately 2½ inches beyond the fuze; not less than 2 inches, nor more than 3 inches.

Arming wire assemblies are classified as type A and type B. Type A has the swivel loop at the end of the arming wire, whereas type B has the swivel loop situated near the middle. Type A will usually be found with bombs equipped with one fuze (an exception is the transverse hydrostatic fuze). Type B will usually be used with bombs equipped with two fuzes. Type A is supplied in sufficient length to provide for any method of suspension and therefore it may be necessary to cut off the excess length when certain methods of suspension are used.

FUZES.

General. Current designs of cylindrical GP and demolition bombs of the "AN" and M-series are equipped with both nose and tail fuzes.

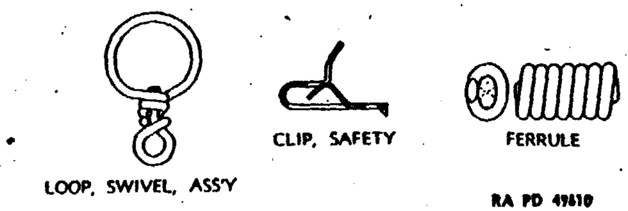


Figure 226a — Arming Wire Components

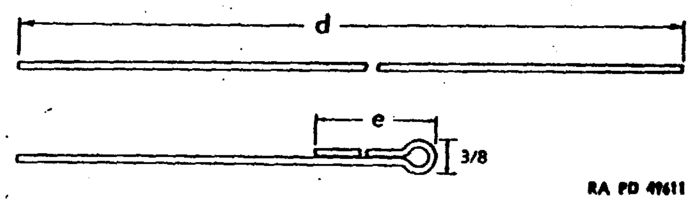


Figure 226b — Arming Wire Components—Continued

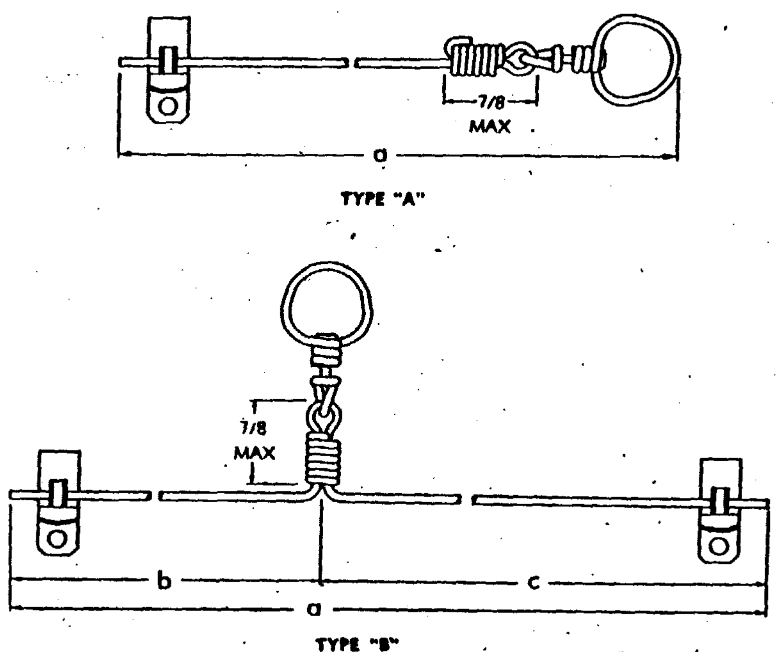


Figure 226c — Arming Wire Assemblies

Two fuzes are used, because it was found that 3 to 5 percent of fuzes fail to function and therefore 3 to 5 percent of the bombs would fall as duds. Two fuzes reduced the duds to 0.2 percent. Therefore, although two fuzes are not necessary for complete detonation of the

bomb, the extra fuze is an insurance that the bomb will function if one fuze fails.

The nose fuze is so designed that the primer, detonator, and booster are integral parts of the fuze. In the tail fuze, the primer detonator is a separable component, while the booster is assembled to the bomb at the time of manufacture in the form of an adapter booster. Most of the fuzes of earlier design were mechanical firing mechanisms containing no explosives.

An arming wire threaded through an eyelet in the arming pin, the vane strap, or the arming vane prevents initiation of the fuze action until such time as the arming wire is withdrawn.

Fragmentation and chemical bombs (excluding incendiary) are equipped with a nose fuze only. Practice bombs are equipped with a nose or tail fuze depending on the bomb.

SAP and AP bombs are designed for tail fuzes only, although SAP may also receive a nose fuze if so desired.

Depth bombs are provided with fuzes that run diametrically through the body or with nose or tail fuzes, depending on the target against which the bomb is used and on the size of the bomb.

Method of Arming. Fuzes are classified according to the method of arming in the following manner:

Arming vane type. This type is armed by means of two or more bladed vanes or propellers which begin revolving when the bomb is released from the plane. The vane is threaded directly to a striker. When the vane has revolved the same number of times as there are threads on the striker, the vane assembly falls free, arming the striker. This type of fuze arms immediately when it is dropped from the plane. It may be used for low-altitude demolition bombing. If it is used, a long delay in action is incorporated in the fuze, allowing the plane to escape after bomb impact, and also protecting the plane and pilot in case the bomb fuze should accidently strike another bomb or the plane fuselage after it has armed.

Arming vane type with mechanical delay. In this type, the vane is not directly threaded to the striker, but is meshed with reduction gears which control the freedom of the striker. The vane must make several hundred revolutions before the fuze is armed. This type of fuze provides a delay in arming and is used with bombs carrying high-explosive fillers, to prevent the fuze from accidently functioning near the plane if it should strike another bomb or the plane fuselage.

Arming pin type. This type is armed when the arming wire is withdrawn from the arming pin which holds the striker in place. This type of fuze arms immediately, and if used on bombs containing a high-explosive filler, it will be found to have a long delay on impact as previously explained.

Arming pin type with time delay. In this type, the fuze is armed by a black powder train. The arming wire, when withdrawn, allows the arming pin to be ejected by its spring. The arming pin frees a firing pin which starts a black powder train burning for a set time after which time the fuze is armed. This type fuze is used in bombs with high-explosive fillers for reasons previously explained.

Time. In this type, the fuze is armed either by the rotation of a vane assembly or ejection of an arming pin. This type is designed to function a predetermined number of seconds after release and is designed to be used against moving aircraft and for several types of pyrotechnics.

Any one of the above types may be designed for use in the nose or tail of the bomb. Nose fuzes, except time, function on impact by direct action; that is, the firing pin is driven into a primer at the instant the nose of the bomb strikes the target, whereas tail fuzes function by inertia. In tail fuzes, the plunger which carries the firing pin continues its forward motion as the bomb is retarded by the resistance of the target. Hence, the action of the nose fuze is slightly the faster.

Action on Impact. Fuzes can be classified according to the action on impact into three general classes:

Instantaneous and nondelay fuzes. Instantaneous and nondelay fuzes are used in demolition bombs to attain surface effect against targets which may be destroyed by the violence of the explosion. Nose fuzes which function immediately on impact are considered instantaneous acting fuzes, while tail fuzes which function immediately on impact are considered nondelay. The action of the tail fuze is slightly slower due to indirect action of impact causing inertia to act on the fuze as compared to the direct action on impact on the nose fuze. Instantaneous fuze action is also used for fragmentation and chemical bombs for above ground distribution of fragments and dispersion of chemical fillers.

Short delay fuzes. The greatest effect of any explosive is obtained when the charge is tamped. Similarly, the best effect of the demolition bomb against a resistant target is achieved if the bomb penetrates and then detonates within the target. For this reason, a great majority of targets against which demolition bombs are used will suffer maximum damage if the bombs are fuzed for delay action. The optimum delay is that which is long enough to allow the bomb to come to rest within the target. At present, the short delay fuzes vary from 0.01 of a second to 0.1 of a second delay in functioning after impact. The extent of the penetration will depend on the type of target, the bomb used, and the height from which it is dropped. In considering ship bombing, it is found that a short delay fuze is in most cases the optimum desired. Such fuzes would permit the

bomb to sink under the water a sufficient depth before exploding to exert maximum force against the armor plate near the bottom of the hull. Against submarines, a fuze which operates on water pressure is used. A short delay fuze would have slight effect if the submarine dived.

Long delay action fuzes. According to earlier regulations, planes could not drop bombs except from safe altitudes if these bombs were fuzed with instantaneous or short delay action fuzes for land bombing. Safe altitudes vary from a minimum of 1,500 feet for the dropping of a 100-pound bomb to the minimum of 4,000 feet for the dropping of a 4,000-pound bomb. For a plane to go below these safe altitudes is dangerous because the effects of concussion and fragments will be felt below such altitudes. It was found that in many cases such altitudes did not enable effective or any bombing. Particularly are such high altitudes not advisable or possible in such cases as the following:

1. Bad weather conditions where the target cannot be seen from high altitudes.

2. Where the climate is too cold to permit high-altitude bombing as in Alaska and Russia.

3. Where a good percentage of effective antiaircraft fire can be avoided by flying at low altitudes.

Long delay action fuzes from 4 seconds to 45 seconds have solved this problem by allowing the pilot to drop his bomb from low altitudes and move out of the effective danger area before the bomb explodes. As the tail fuze is usually the fuze designed for long delay, when such bombing is to be done and the type of bombing is not known until the target is reached, the nose fuze is made inoperative. The nose fuze can be made inoperative by removing the vane or by cutting the arming wire and wrapping it around the vane. If it is understood before the planes take off that the bombing is to be low altitude, both nose and tail fuze may be assembled to the bomb which provide for long delay.

Long delay fuzes of 4 to 5 seconds are found utilized for low-altitude sea bombing (masthead bombing). Such bombs are dropped near the side of a ship to allow for effective action below the water surface while long delay fuzes of 8 to 15 seconds are used for low-altitude land bombing (hedge hopping).

For special use, such as preventing immediate reuse of bombed areas and for moral effect, long delay fuzes which vary from one hour to several days may be found in use.

Fuze Nomenclature. Army fuzes will either be found with "Mk." and the appropriate mark number in Roman numerals or "M" with the appropriate M number in Arabic numerals. The Mk. series are the old fuzes and are obsolete. The M series of bomb fuzes will start at

100 and at the present time can be found with numbers 100 to 126 inclusively. These fuzes may or may not be S&M. When these fuzes are interchangeable for Navy or Army use, the letters "AN—M" will precede the number to indicate the interchangeability and also that the fuze is Army design.

Navy fuzes were formerly found with the letters "Mk." and the appropriate mark number in Roman numerals. Later the letters "Mk." were followed by the appropriate mark number in Arabic numerals. For example, Fuze Mk. XXIV became Fuze Mk. 24. When these fuzes are interchangeable for Navy or Army use, the letter "AN—Mk." will precede the number to indicate the interchangeability, and also that the fuzes are Navy design. Recently, in order to avoid confusion in Navy fuzes, it was decided by the Navy to use the following system of numbering. All artillery fuzes were to be numbered from 1 to 99. All miscellaneous fuzes, such as used in torpedoes would be numbered from 100 to 199, whereas all bomb fuzes would be numbered from 200 to 299. For example Fuze Mk. XXIV which became Fuze Mk. 24, today should be changed to Mk. 224, and if it is also for Army use the fuze nomenclature should read AN-Mk. 224.

POWER AND EFFECT OF BOMBS.

Action and Effect of Explosives. The destructive effect of a bomb is in most cases due to the detonation of the high-explosive charge, and consequently it will be of interest to consider briefly some of the ways in which a high explosive acts.

In general, a high explosive consists of an unstable compound including nitrogen. The results of an explosion are to convert the whole of the explosive into gas. This may result in a volume of gas 10,000 times that of the explosive in solid or liquid form.

Thus, a bomb containing 10 pounds of explosive occupying $\frac{1}{10}$ cubic foot tends to produce 1,000 cubic feet of gas. At the bomb, the instantaneous pressure is momentarily of the same order as would be required to compress the gas back to solidity; about 10,000 atmospheres or 147,000 pounds per square inch. Fragments of a bomb may acquire velocities comparable to those of rifle bullets (nearly 3,000 ft per sec) and cause great impact effects.

There are two ways in which an explosive may act. If the bomb is exploded in the open, there is a blast effect accompanied by the dispersion of missiles which are fragments of the bomb case. If, on the other hand, the bomb is exploded deep in the earth or water, there is a lifting and heaving of the surrounding substance which is sometimes described as a mining effect.

A high explosive which is well tamped has about four and one half times the shattering effect that the same amount of explosive would have if it were exploded in contact with the same object, but in the open. Thus, if it required 10 pounds of TNT to breach a wall with

the explosive properly placed and tamped, it will require 45 pounds to produce the same effect if the explosive is simply lying against the wall. The same effect of tamping is obtained when a bomb explodes inside a building.

In 1941, a standard 500-pound demolition bomb was dropped from an altitude of 14,000 feet into a reinforced concrete slab 48 inches thick. The effect of the detonation was to pulverize and excavate the position of the slab immediately below the bomb and to shatter the remainder of the slab. The area excavated was 27 square feet and the area broken in the massive block was 400 square feet.

Against personnel, blast effectiveness is limited to very short distances. A hundred and ten feet is listed as the approximate maximum distance at which the blast of a 2,000-pound bomb is effective against personnel. A basis for this estimate was found in the explosion at Picatinny Arsenal, where a watchman received only slight injury when 775,000 tons of TNT detonated at a distance of 1,500 feet.

Fragmentation bombs are more dangerous than demolition bombs in the open. The fragments of the bomb, not the explosive charge, do the most damage when a bomb is detonated in the open. These bombs are intended for attack on troops, trucks, airplanes on the ground or in the air, and other light materiel and is designed to produce the most fragments possible.

HORIZONTAL DANGER RADIUS OF BOMB CASING FRAGMENTS

Bomb	Maximum Danger Radius of Fragments from Point of Detonation
100-lb, 300-lb, 600-lb, 1,100-lb	1,000 yd
2,000-lb	2,000 yd

BLAST EFFECT ON PERSONNEL

Bomb	Approximate Maximum Distance That Blast Is Effective on Personnel
100-lb	40 ft
300-lb	55 ft
600-lb	75 ft
1,100-lb	90 ft
2,000-lb	110 ft

TECHNIQUES OF BOMBING.

There are four methods of bombing used:

High-level Bombing or Horizontal Bombing. Planes travel at very high altitudes to drop their bombs on enemy targets. Very good bomb sights are essential in this type of bombing.

Dive Bombing. This is done at an angle of 70 to 75 degrees. It was developed by the United States government, but put into extensive use by the Germans.

Glide Bombing. Shallow dive bombing at an angle of 45 degrees or less for planes which cannot withstand the stress and strain involved in dive bombing techniques.

Low-level Skip or Hedge Hop Bombing. Bombs dropped from levels of 50 to 200 feet. Such bombs will ricochet; this is very effective against merchant shipping.

FURTHER REFERENCES: All references may be found at the close of this section.

Chapter 2

G.P. (General Purpose) Bombs

GENERAL.

With the design of the 2,000-pound Mk. I Bomb as cylindrical, a new innovation in American bomb development was initiated. A new series of bombs was developed and later standardized in 1939. This series of bombs was known as the M series.

The M series demolition bombs were cylindrical in shape with a box type tail assembly. The bomb body was made in one piece. This provided for four advantages over the Mk. series, namely:

The bomb case was stronger due to the absence of welds.

The bomb case was easier to manufacture and cheaper in cost.

The bomb itself was easier to load with explosive.

The shape of the bomb facilitated handling in the field. The M series of demolition bombs had the following nomenclature: 100-pound M30; 300-pound M31; 600-pound M32; 1,100-pound M33; 2,000-pound M34.

Shortly thereafter, the above series of demolition bombs were modified and several sizes of bombs were replaced by others. To make Army and Navy bombs interchangeable, a 500- and 1,000-pound demolition bomb were standardized and the 600- and 1,100-pound bombs were declared standard for issue only. To allow for Army, Navy, and British interchangeability of bombs, the 250-pound bomb was standardized and the 300-pound bomb which would not conveniently fit into British bomb racks was declared standard for issue only. In accordance with the above, all new bombs being manufactured had welded on their bomb bodies a single suspension lug at the center of gravity to allow for use in British single suspension racks and several of the Navy planes which carried single suspension racks.

Also the new bomb was improved by the substitution of the tail base plug instead of a rear closing cap to close the tail of the bomb. The lip of the rear closing cap would snag as the bomb penetrated the target pulling off the cap, fuze, and booster. This resulted in a low order detonation or dud. The tailbase plug screws into an internally threaded bomb body, overcoming this disadvantage.

To indicate these changes, a new nomenclature was utilized. All these new bombs were designed as AN to indicate Army and Navy use with the appropriate Arabic numerals preceded by a model or mark number to designate Army or Navy design respectively. The letters GP (general purpose) were added in place of demolition to conform with British nomenclature. The word "demolition" which had previously been restricted to what today is known as GP bombs received a new meaning to include all of the new bombs, which arose because of the complexities of modern warfare, such as general purpose, light case, semiarmor-piercing, armor-piercing, and depth bombs having a demolition effect. Because of their similarities, light case and the old demolition bombs are considered with general purpose bombs.

In considering a particular type of bomb, it is advisable to analyze one example of that type, for with slight variations the other bombs in that group are exactly the same. A typical example of GP bombs is the AN-M 500-pound bomb.

The early method of manufacture for GP bombs or their predecessor, the M-series, was made by swaging the end of a piece of seamless steel pipe to form the nose. The tail end was tapered down, using the same method. The shape of the bomb body was, therefore, cylindrical with tapered nose and tapered tail. Later, forging was also used; that is, a solid ingot of metal was forged into a cylinder with one end closed. The open end was tapered and trimmed, and the closed end was machined down to proper dimensions for the nose. As the demand for bombs increased, any case that could meet the requirements was accepted. This allowed for the use of welding, since techniques in welding have improved tremendously in recent years. Today, bomb cases will be found made of cast steel noses welded to seamless steel pipe, for example.

Dimensions of the Bomb Case. Regardless of the method of manufacture, a cross section of a bomb case will be essentially the same. The nose is relatively thick at the point where the fuze is attached, and it will taper gradually back through the ogive until the cylindrical side walls are reached. The cylindrical side walls are of uniform thickness and will continue through the tapering tail. That portion of the tail which is threaded internally for the tail base plug is thickened to make up for the loss of material through threading.

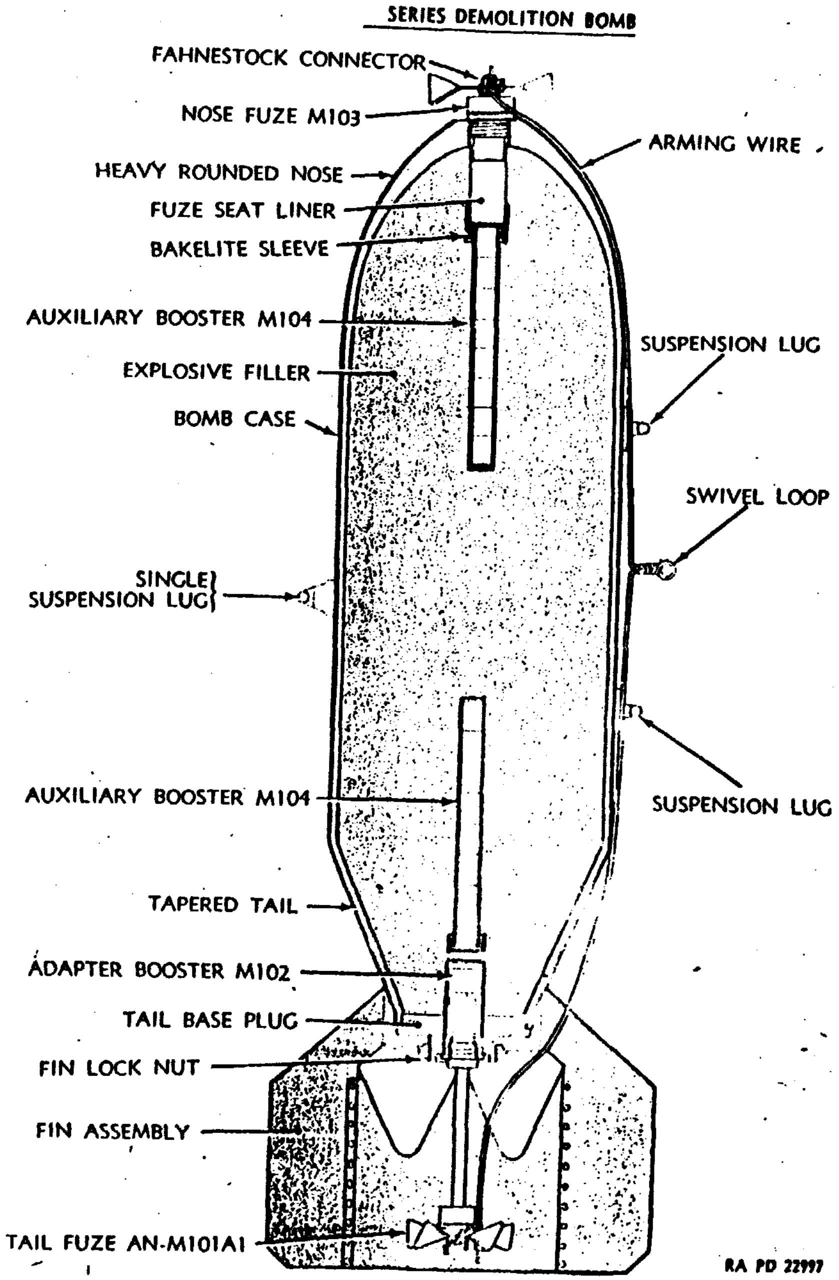


Figure 227 — BOMB, G.P., 500-pound, AN-M43

To illustrate, the minimum dimensions of the AN-M 500-pound GP bomb are as follows:

Bomb Case Section	Thickness in Inches
Nose	1.25
3 inches in back of nose	1.10
6 inches in back of nose	0.56
9 inches in back of nose	0.49
12.2 inches in back of nose	0.30
Side walls	0.30
Taper on tail	0.30
Portion of tail threaded for tail base plug	0.318

These figures can be considered typical, provided that they are, in any given case, proportioned to the size of the bomb.

Body Fittings. The nose of the bomb case is drilled and tapped for the fuze seat liner and nose fuze. The tail opening is threaded internally to receive an externally threaded base plug. This is a much more efficient construction than that employed in the past with rear closing cap. The rear closing cap is internally threaded so as to screw into an externally threaded bomb body. The lip produced in this type of construction has been found to catch as the bomb penetrates targets, pulling off the cap and tail fuze, and resulting in a low order detonation or a dud. The tail base plug is drilled and tapped in its center for the adapter booster. A collar is machined and threaded on the back side of the base plug for the fin locking ring which holds the fin in place and is internally threaded to receive an adapter booster. The adapter booster is internally threaded to receive the tail fuze. Welded to the bomb body are two Army suspension lugs, 14 inches apart, each 7 inches away from the center of gravity. A single suspension lug is welded to the opposite side of the bomb body at the center of gravity.

Construction of the Fin. The fins used on GP bombs are box type, and because of their structure they are very stable. The foundation of the fin assembly is a square metal box with top and botton open. One end of each side of the box ends in a vane, and is fastened to the end of another side of the box. These stabilizing vanes are at an angle of 135 degrees from the sides of the box. The ends of the vane extend beyond the end of the box, and are so cut that the extensions will bisect the angles of the box and meet in a common center. Fastened to these extensions is a shallow drawn cup or sleeve made to fit over the rear end of the bomb case. The sleeve conforms to the bomb case and fits snugly over the collar on the tail base plug. The fin locking ring or fin lock nut is threaded to the collar, jamming the base of the sleeve against the rear of the base plug and locking the fin assembly to the bomb case.

Painting. Until March 1942, all GP bombs were externally painted yellow with black stencil. Since March 1942, all bombs have been painted olive drab with black stencil. For identification, the bomb bodies have a 1-inch yellow band around the tail and nose and a ¼-inch yellow band around the center of gravity. Internally, all GP bombs are painted with acidproof black paint to prevent reaction of high-explosive filler with the metal bomb case.

Explosive Filler. The standard filler for the GP bomb is amatol in any of its percentages. Alternate fillers are TNT and composition B. When amatol is used, a TNT seal may or may not be used at the nose and tail openings. The TNT seal is advisable if the bomb is to be stored for long periods of time, because of the airtight seal it would form, preventing the ammonium nitrate in the amatol from reacting with the moisture in the air. The weight of 50/50 amatol in a 500-pound bomb is about 265 pounds, while for TNT loaded bombs the weight of TNT is about 280 pounds. In general, the explosive content is about 50 to 55 percent of the total weight of the GP bomb.

Fuze Seat Liner. The fuze seat liner is a steel cup which may be cadmium plated. It has a flange which is externally threaded so as to screw into the nose of the bomb body. The fuze seat liner serves to form a seat for the fuze when the latter is to be inserted into the bomb body, and also with the aid of a bakelite sleeve, it holds the nose auxiliary booster in line with the fuze while the bomb is being loaded. Recently, the construction of the fuze seat liner was changed from a 2-piece affair to a 1-piece design. It was found, in many cases, that the base of the fuze seat liner, which was a separate part, would allow the amatol filler to seep or run into the liner itself. The 1-piece construction helps to eliminate this condition. The outside of the fuze seat liner is painted acidproof black as in any metal component which comes into contact with explosive filler such as amatol.

Bakelite Sleeve. The bakelite sleeve is an open hollow bakelite cylinder with an internal shoulder so designed as to hold the auxiliary booster. The other end fits around the fuze seat liner. The position of the bomb in pouring, nose down, allows the bakelite sleeve in conjunction with the fuze seat liner to hold the auxiliary booster at the nose in place.

Boosters. An adapter booster is found in the tail of the bomb body only and is used to seat the tail fuze and amplify the detonating wave of the tail fuze detonator. All nose fuzes for GP bombs have the boosters incorporated in the fuze, for there is no adapter booster located at the nose of the bomb body. Correspondingly, all tail fuzes for bombs do not have boosters incorporated in the fuze because the bomb body has its own adapter booster.

Auxiliary Booster M104. The M104 Auxiliary Booster consists of a booster charge of tetryl (0.5 pound) in a bakelite casing 1 foot long. It is closed at the top with a felt disc, under a threaded bakelite cap. The cap of the booster casing rests on the shoulder of the bakelite sleeve as described previously. The M104 Auxiliary Booster is also found in the tail end of the bomb body. This is true of all GP bombs except the 100-pound GP bomb and the 4,000-pound LC bomb, each of which has one auxiliary booster only. The 100-pound GP bomb is too small to use two auxiliary boosters, so that the M104 is only found in the nose of the 100-pound bomb. The 4,000-pound bomb uses one large auxiliary booster which extends the entire length of the bomb. This auxiliary booster is the M111. It has approximately 3.4 pounds of tetryl and is 7 feet long. It is held in position at the nose in the same manner as described for the M104 Auxiliary Booster. For all other GP bombs, the M104 Auxiliary Booster is held in the tail by the amatol solidifying around the casing. Special equipment is utilized to form a cavity for the auxiliary booster and to hold it in place while the amatol solidifies. Such equipment is removed when the tail auxiliary booster is properly in place.

The use of auxiliary boosters is necessary to insure the high order detonation of the large quantity of comparatively insensitive bursting charge which is found in the GP bomb.

Adapter Booster M102. The M102 is threaded at the top with outside threads for screwing into the tail base plug. It is internally threaded to receive an Army tail fuze. At the bottom, the adapter is threaded to receive the booster casing which contains a charge of tetryl. A small closing cup located in the housing between the fuze cavity and booster charge is filled with tetryl and acts as a lead charge. The adapter booster is made of steel, and may be cadmium or zinc plated.

Adapter Booster M115. This recently adopted booster is similar to the M102 except that the diameter of the M115 is larger, making it possible to use the AN-Mk. 230 Navy Hydrostatic Tail Fuze. To reduce the diameter of the adapter to receive Army fuzes, a threaded sleeve is screwed into the M115 Adapter Booster. To make use of Navy fuzes, the sleeve must be removed with a special stud wrench having two studs which fit into two holes in the face of the sleeve. All GP bombs except the 500-pound AN-M64, the 1,000-pound AN-M65, and the 2,000-pound AN-M66 use the M102 Adapter Booster. The AN-M64, AN-M65, and AN-M66 use the M115 Adapter Booster, and are replacing GP bombs of like size.

Shipping Plugs. To close the nose and tail fuze cavities, shipping plugs are screwed into the nose threads and adapter booster threads. These plugs protect the threads and prevent entrance of dirt into the

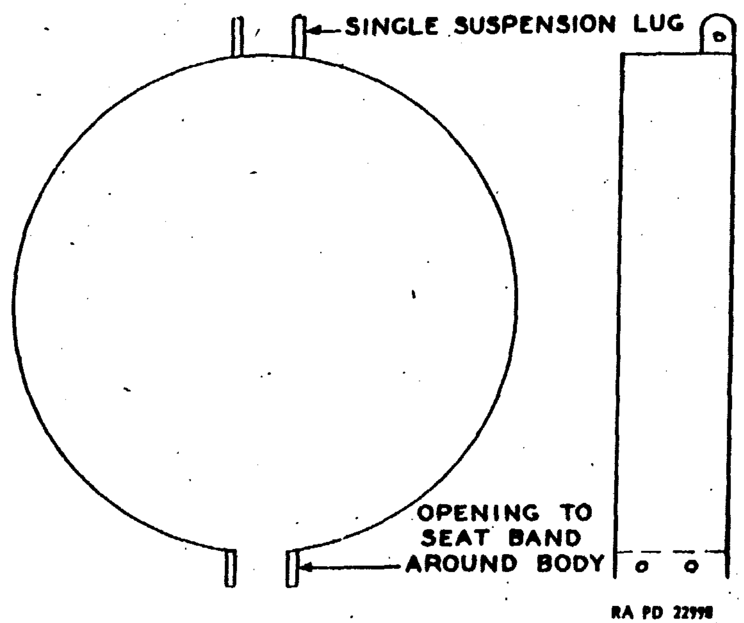


Figure 228 — Suspension Band

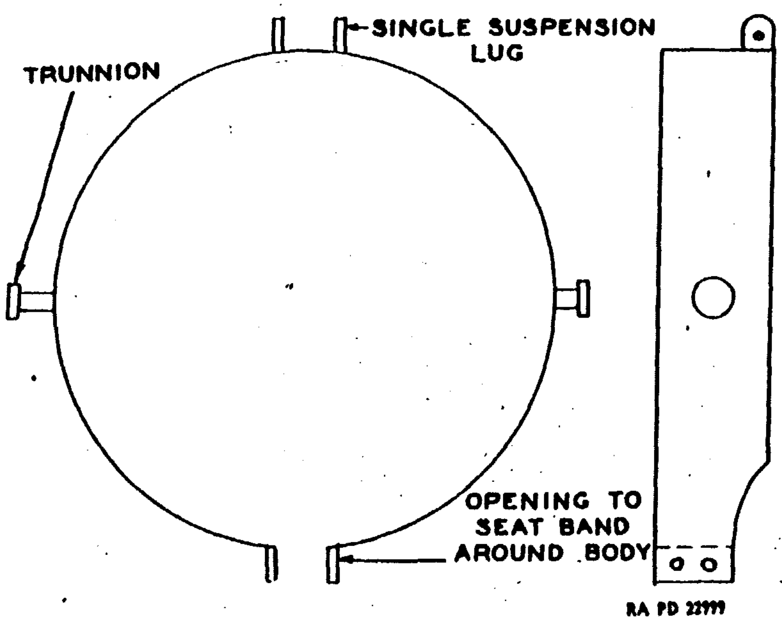


Figure 229 — Trunnion Band

fuze cavities. This is particularly necessary because bombs are never shipped with fuzes assembled.

Arming Wire. Type B arming wire is generally used for all GP bombs. This type has a diameter of 0.64 inch. The swivel loop is attached somewhat off center of the length of the wire with the longer end of the wire designed to be inserted in the tail fuze. As the standard bomb fuzes for GP bombs are of the arming vane type both at the nose and tail positions, two safety clips (phosphor-bronze Fahnestock connector No. 3) are required for the complete round.

Trunnion Band. Previously it had been mentioned that to adapt Army bombs for Navy use, a single suspension lug and a means of attaching bombs to special racks used in dive bombing had to be provided. To accomplish these necessities, the bombs were provided with trunnion bands. A trunnion band is merely a steel ring which can be placed around the circumference of the bomb and bolted together at the ends to secure it in place. Opposite the point where the band is bolted together, a single suspension lug is riveted and welded to the band. This single lug is for use in single suspension. Two pivot points or trunnions are provided on the same band for dive bombing racks. Each trunnion is 90 degrees from the suspension lug and the ends of the band. Thus, the trunnions are on the same plane and 180 degrees from each other on the band. They are riveted and welded in place. The trunnion band is bolted around the center of gravity of the bomb with the bolt on the same side of the bomb as the double suspension lugs. The trunnions fit into a yoke arrangement that lowers the bomb out of the propeller arc when it is released from the bomb shackle. Trunnion bands can be considered used for one or two of three purposes: to provide trunnions for dive bombing; to provide a third lug for single suspension; to provide a hoisting lug.

All trunnion bands serve to provide trunnions for dive bombing, and some trunnion bands serve for this purpose only. Others act to provide trunnions for dive bombing and also provide a third lug. The final group of trunnion bands acts to provide trunnions for dive bombing and a lug for hoisting. The M1 and M2 Trunnion Bands previously described act to provide trunnions for dive bombing and also furnish a single suspension lug, since the bomb for which they are provided has no lug for single suspension. The M1A1 acts to provide trunnions for dive bombing and a lug for hoisting.

Trunnion bands and the bombs they are used with are listed below:

M1; 500-pound M43 Demolition Bomb

M1A1; 500-pound AN-M43 and AN-M64 GP Bombs; also the 1,400-pound M63 AP Bombs

M2; 1,000-pound M44 Demolition Bomb

M2A1; 1,000-pound AN-M44 and AN-M65 GP Bombs

M3A1; 1,000-pound M52 and M52A1 AP Bombs; also the 900-pound M60 AP Bomb and 800-pound M61 Bomb
M4; 500-pound AN-M58 and AN-M58A1 SAP Bombs
M5; 1,000-pound AN-M59 SAP Bomb
M6; 600-pound M62, M62A1 and M62A2 AP Bombs

Suspension Bands. The 100-pound M30 Demolition Bomb uses a suspension band which is a steel band that fits around the bomb body. It provides the third lug which is attached to the band. The band is known as the M1, and adapts the bomb for single lug suspension racks for dive bombing purposes.

Suspension bands have one main purpose, and that is to provide an additional lug where desired. Some suspension bands provide besides the single lug, trunnions for dive bombing.

Hoisting Bands. These are bands which have one or two lugs for hoisting purposes only. They are used primarily by the Navy. Army hoisting bands are in the form of trunnion bands or suspension bands.

FUZE, Nose, M103 and AN-M103.

General. This is an arming vane type with mechanical delay in arming. It is used in all GP bombs, the M-series demolition bombs which preceded the GP series, the 4,000-pound LC bomb, and in the 650-pound depth bomb. It is used for high-altitude land bombardment, and also against water targets. Its action on impact is selective, instantaneous or 0.1 second delay. The length of this fuze is about 7 inches, and it weighs about 3.7 pounds. It is packed 1 per container, 25 containers per box. The vanes are packed separately in the same container.

Description. The selective action of this fuze is obtained by use of two firing systems, one for instantaneous action, the other for delay; both are contained in the upper part of the body. The detonator is mounted in a slider located below the firing pins, and is normally held out of firing position by the arming stem. In this "out of firing" position, the detonator communicates with a cavity into which the force of the explosion of the detonator could expand should the detonator function prematurely. In the arming of the fuze, the arming stem serves as a stop to limit the movement of the slider to the position appropriate for the required action, instantaneous or short delay, depending on the position of the setting pin. Delay arming is accomplished by interposing a reduction gear train between the arming vane and the arming screw to reduce the movement of the arming screw to 1 turn for approximately 65 revolutions of the arming vane. Arming discs between the striker and the body of the fuze prevent movement of the firing pin prior to arming. The detachable arming vane is held in position by a spring vane-holder ring.

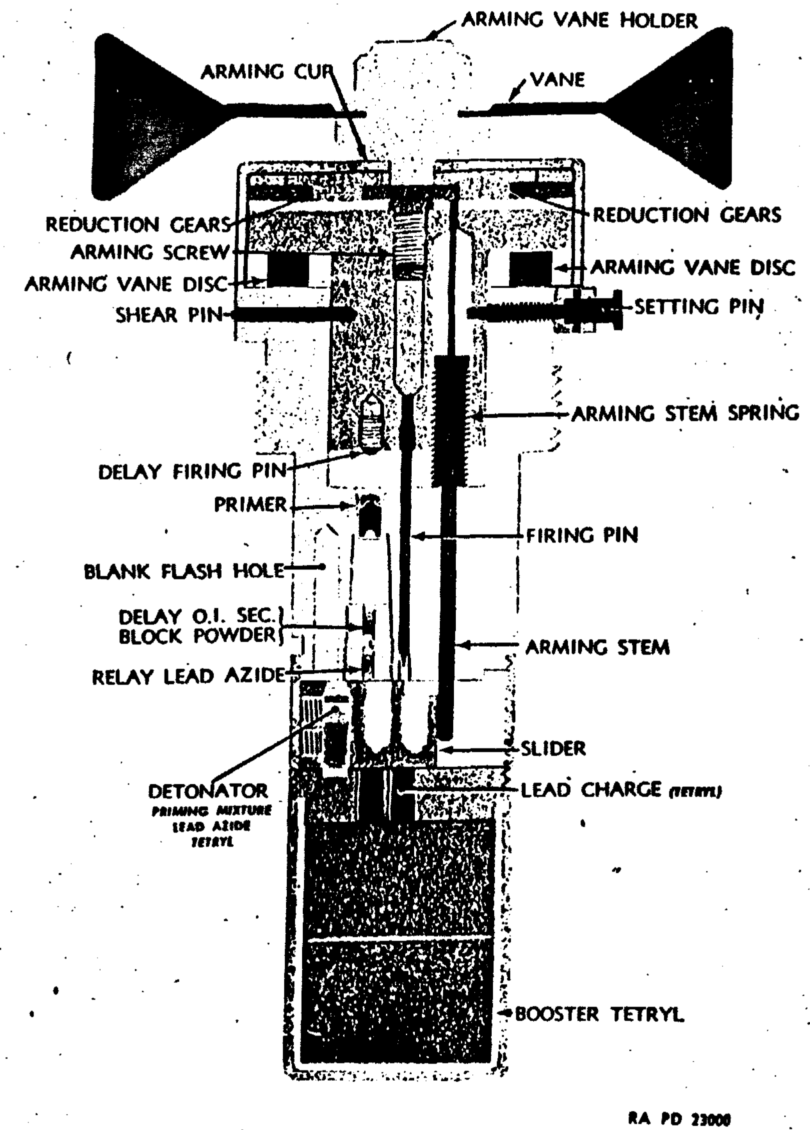


Figure 230 — FUZE, Bomb, M103 (Nose)

Eyelets in the vane strap which aline with corresponding eyelets attached to the vane cup are provided for the arming wire. The fuze may be set at will to instantaneous or 0.1 second short delay.

The reduction gear train consists of a drive gear which is directly connected to the arming vane. The drive gear rotates with the arming vane. The drive gear is in mesh with two eccentric gears. Upon the hubs of the eccentric gears rides an external gear. The external gear executes pure revolution about the axis of the drive gear and meshes with an internal gear, to which the arming screw is directly attached, at only one point on its circumference. The reduction achieved is 65 revolutions of the vane to 1 revolution of the arming screw.

Function when set for delay action. The bomb is dropped and the arming wire is retained in the plane. The arming vane is now free to be rotated by the air stream. The rotating arming vane, acting through the reduction gear train, slowly unscrews the arming screw which carries the vane cup with it. This movement of the vane cup uncovers the arming discs and permits them to be ejected by the flat U-spring. The striker is now held in place by a shear pin and the setting pin which acts as a secondary shear pin.

Simultaneously, this movement of the vane cup permits the arming stem, due to the action of the arming stem spring, to move partially out of the slider cavity until the shoulder of the arming stem comes into contact with the setting pin. When set for delay action, the setting pin is in the deep slot of the body and therefore protrudes into the arming stem cavity. The slider is now free, and due to the action of its spring it is forced to move toward the end of the slider cavity until its shoulder comes into contact with that part of the arming stem which still protrudes into the slider cavity. It is prevented from moving rearward by a slider lock which consists of a cupped spring which slips into a step-like cavity in the slider. It allows the slider to move forward but not backward. The slider is prevented, however, from moving forward by the arming stem. In this locked position, the detonator which is carried by the slider is directly in line with the delay explosive train. The instantaneous firing pin is now directly over a blank hole in the slider while the arming stem is over a second blank hole in the slider. This is to prevent these elements from interfering with action on impact, and also serves as additional locking elements after impact.

On impact, the striker is forced inward, breaking the shear pin and setting pin. The instantaneous firing pin and arming stem move into the blank holes in the slider. The delay firing pin strikes a primer. The flame from the primer ignites a black powder delay pellet which burns for 0.1 second. A relay of lead azide is initiated by the black powder flame. The detonating wave produced functions the detonator of priming mixture, lead azide, and tetryl. The detona-

tor functions the lead charge of tetryl which detonates the booster of tetryl in the base of the fuze. The wave from the fuze detonates the auxiliary booster of tetryl in the bomb body and the explosive bursting charge.

Function set for instantaneous action. The bomb is dropped and the arming wire is retained in the plane. The arming vane is now free to be rotated by the air stream. The rotating arming vane, acting through the reduction gear train, slowly unscrews the arming screw which carries the vane cup with it. The movement of the vane cup uncovers the arming discs and permits them to be ejected by the flat U-spring. The striker is now held in place by a shear pin and the setting pin which acts as a secondary shear pin.

Simultaneously, this movement of the vane cup permits the arming stem, due to the action of its spring, to move up until its shoulder strikes the top of the striker body. The setting pin engaged in the shallow slot does not interfere with the movement of the arming stem. The slider cavity is now entirely free of the arming stem. The slider, due to the action of its spring, moves until it strikes the fuze housing. It is prevented from moving rearward by the slider lock. In this locked position, the detonator which is carried by the slider is directly underneath the instantaneous firing pin and over a second lead charge of tetryl. The arming stem is directly over the innermost blank hole in the slider and therefore does not interfere with action on impact but serves as an additional locking element after impact.

On impact, the striker is forced inward breaking the shear pin and setting pin. The arming stem moves into the blank hole in the slider. The instantaneous firing pin strikes the detonator of priming mixture, lead azide, and tetryl. The detonating wave produced functions the lead charge of tetryl which in turn detonates the booster of tetryl located in the base of the fuze.

Comparison between M103 and AN-M103. Normal arming of the M103 Bomb Fuze requires from 1,000 to 3,500 feet of air travel or 525 revolutions for delay action, 820 revolutions for instantaneous. Dive bombing and low-altitude bombing over water have produced bomb failures because the M103 Fuze was not completely armed at the time of impact. This fuze, when used for low-altitude water impact bombing, must be partially armed before dropping. Fuzes partially armed and set for instantaneous or delayed action will become completely armed at the time of impact when dropped from minimum combat altitudes.

The M103 Bomb Fuze may be partially armed by backing off the arming vane until 1/8 inch of the safety discs is exposed by the vane cup. This requires approximately 250 turns. Tolerance variations in manufacture and assembly of M103 Fuze may cause exposure of one-eighth inch of safety discs before making 250 turns of arming vane. Such a fuze is partially armed when one-eighth inch of safety discs is exposed. The arming vane must not be backed off more than 250 turns.

The Fuze AN-M103 arms within the minimum combat altitudes or within 435 to 935 feet of air travel or 220 revolutions for delay and 330 for instantaneous are required. An additional change was the modification of the arming vane to one somewhat smaller in diameter to make it more stable.

FUZE, Tail, AN-M101A1.

General. This is an arming vane type of fuze with mechanical delay. It is used in 500- and 600-pound GP bombs and M-series demolition bombs which preceded the GP series. 500-pound SAP bombs also utilize this fuze. It is used for high-altitude land bombardment and also against water targets. Its action on impact depends on the primer detonator used. It can vary from nondelay to 0.1 second delay. The arming time is approximately 720 revolutions of the arming vane. It is about 12 inches long, weighs about 2.9 pounds, and is packed 1 per container, 25 per box. The vanes are packed separately on spindles in the same box.

Description. This fuze is designed so that the delay time may be varied by changing the primer detonator. As shipped, the Primer Detonator M14 with 0.025-second delay is assembled to the fuze. This may be replaced in the field by use of the M14 Primer Detonator having a nondelay, a 0.01-second delay, or a 0.1-second delay by unscrewing the primer detonator, which appears as a knurled ring at the base of the fuze, and by screwing in the primer detonator assembly of the desired delay. The work is done by hand since the use of tools is neither necessary nor permitted. The length of the firing stem tube is 6.6 inches. Housed in the fuze body are the firing pin, primer, delay element, and detonator. The plunger is held in place by means of an arming stem which passes through the arming stem tube to the upper portion of the fuze. A cotter pin passes through the fuze housing and plunger at the point where the external threads are located for screwing the fuze into the adapter booster. This cotter pin must be removed therefore before the fuze can be assembled to the bomb.

Attached to the upper end of the arming stem is a cup in which is housed the delay arming mechanism. Delayed arming is obtained by a reduction gear train. Essentially, the reduction gear train consists of 3 gears. The idler gear is fixed to the bearing cup by means of a pinion called the idler pinion. The bearing cup is directly attached to the arming vane. The idler gear is in mesh with a stationary gear and a movable gear. The stationary gear has 29 teeth and is on a stationary gear carrier which is held to the stem cup by means of a

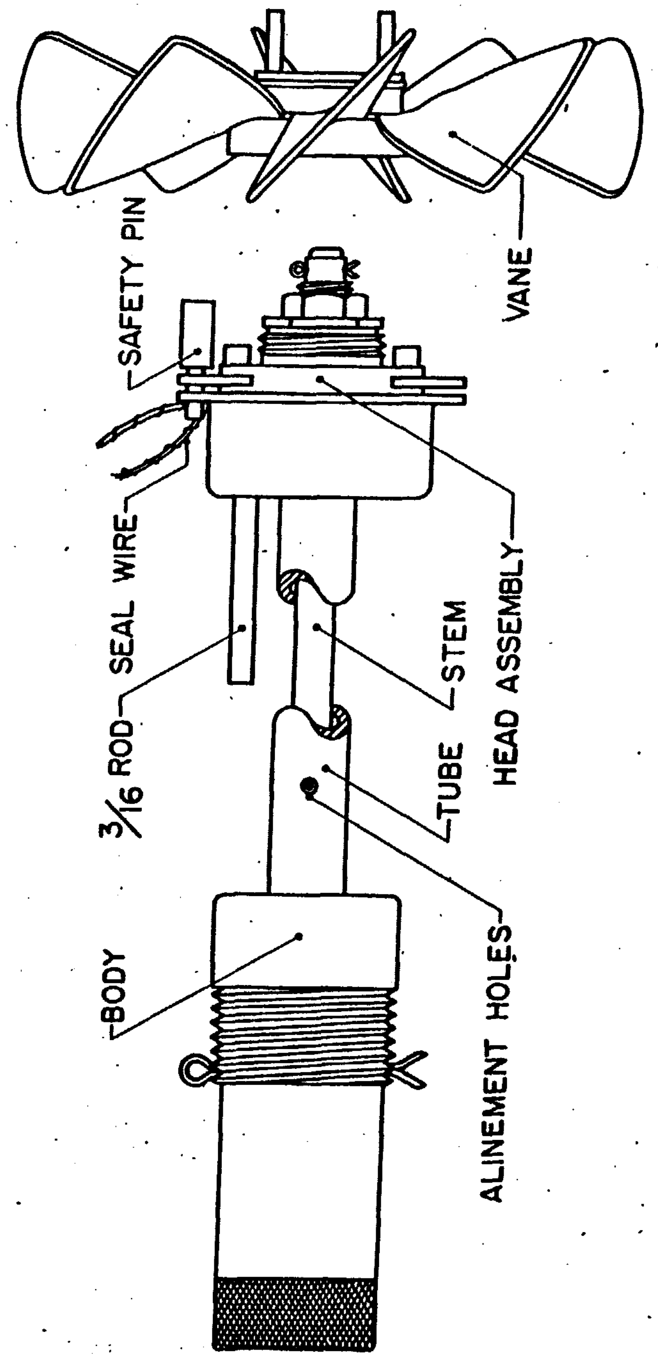


Figure 231 — FUZE, Bomb, AN-M100A1

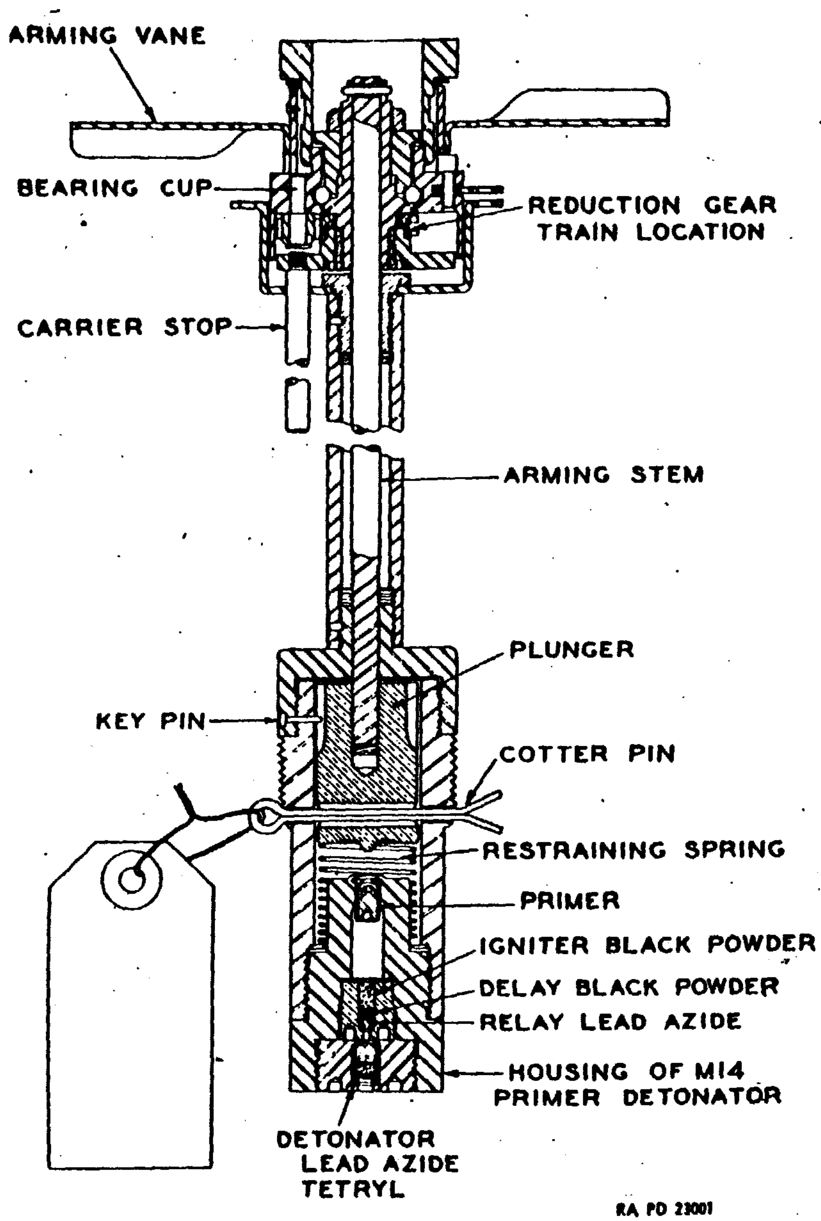


Figure 232 — FUZE, Bomb, AN-M101A2 (Tail)

carrier stop. This carrier stop will prevent any rotation of the stationary gear assembly. The movable gear has 30 teeth. Because of the differential number of teeth in the stationary and movable gears, the movable gear is caused to rotate 1 tooth for each turn of the idler gear about the 2 gears. This is 1 complete turn for 30 turns of the vane since the vane rotates the idler gear directly. The movable gear is attached to the arming stem. Consequently, as the movable gear rotates so does the arming stem. The stem turns $\frac{1}{30}$ of a thread for each turn of the vane or 1 complete thread for 30 turns of the vane.

Function. The bomb is dropped and the arming wire is retained in the plane, thereby permitting the arming vane to be rotated by the air stream. The rotating arming vane acting through the reduction gear train unscrews the stem from the plunger (approx. 720 revolutions), thereby arming the fuze. The plunger is now held away from the primer of the M14 Primer Detonator by a light coil restraining spring. After a total of approximately 1,260 revolutions, the entire arming vane, reduction gear train, and arming stem assembly is carried clear of the fuze by the air currents passing through the tail fin assembly. During this entire process of arming, a key pin prevents the rotation of the plunger as the arming stem unscrews.

Upon impact, the motion of the bomb is arrested and the plunger compresses the restraining spring causing the firing pin, which is milled into the end of the plunger, to strike the primer of the M14 Primer Detonator. The flame produced ignites a black powder igniter charge which in turn ignites the delay of black powder. This burns for the prescribed time and ignites a relay of lead azide. The detonating wave from the relay functions the detonator of lead azide and tetryl.

Primer Detonator M14 and M14A1. The Primer Detonator M14 or M14A1 screws into the base of the Tail Fuze AN-M100A1, AN-M101A1, AN-M102A1, AN-M100A2, AN-M101A2, or AN-M102A2. The primer detonator consists of a housing so threaded and machined as to receive a primer, delay, and detonator assembly. Around the outside of the housing will be found threads which are designed to screw into the base of any of the fuzes previously named. The base of the primer detonator is stamped with the appropriate delay and is painted to indicate the various delays as follows:

0.1-second delay....................Entire base is painted black
0.025-second delay ....¼ base is painted black
0.01-second delay ....⅛ base is painted black
Nondelay........................Entire base is painted white

The primer detonator delay which comes assembled with the fuze

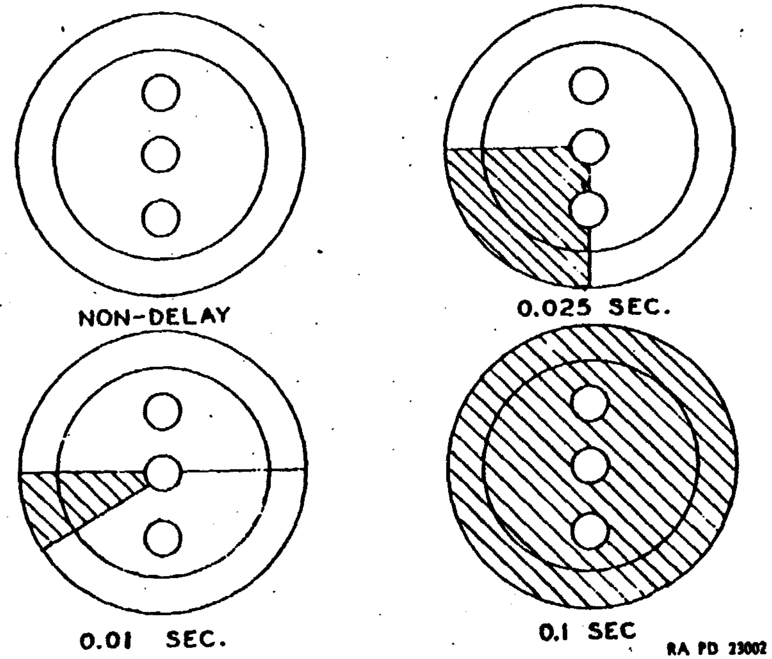


Figure 233 — Marking of M14 Primer Detonators

is at present the 0.025-second delay. The explosive train consists of the following elements in position as listed:

Delay Holder Assembly	Detonator Holder
Primer	Upper detonator lead azide
Igniter black powder	Lower detonator tetry
Delay black powder 0.025 sec	
Relay lead azide	

All other delays for the M14 or M14A1 Primer Detonator have the same explosive train elements with a difference, of course, in the delay pellet burning time, if any is present. The nondelay and 0.1-second delay primer detonator does not have an igniter charge of black powder.

FUZE, tail, AN-M100A1 and AN-M102A1. These fuzes are entirely the same as the AN-M101A1 described above in so far as function and description are concerned, differing only in the length of the arming stem tube in order that the arming vane will be properly positioned in the air stream. The arming stems are: 3.6 inches on the AN-M100A1: 6.6 inches on the AN-M101A1; and 10.6 inches on the AN-M102A1. Longer stems are necessary in larger bombs.

FUZES, Tail, M100, M101, and M102. These fuzes differ from the AN-M100A1, AN-M101A1, and AN-M102A1 only in that they

have a primer detonator of 0.1-second delay firmly attached. Delay cannot be changed.

FUZE, Tail, AN-M100A2, AN-M101A2, and AN-M102A2. Arming of fuzes listed above, having but the A1 modification, requires from 1,000 to 3,500 feet of air travel. Dive bombing and low-altitude bombing over water have produced bomb failures because the bomb fuzes were not completely armed at the time of impact. These fuzes, when used for low altitude water impact bombing, must be partially armed before using. Fuzes partially armed as described below will become completely armed at the time of impact when dropped from minimum combat altitudes.

To partially arm the AN-M101A1 or M101, or any others in the same series, one must measure the length of the $\frac{3}{16}$-inch diameter rod (stationary gear carrier stop) extending beyond the cup. This length should be approximately 1.5 inches before partial arming. The vane is rotated clockwise approximately 350 turns. The rod is again measured. Its length should now be 0.4 inch less or approximately 1.1 inches. If the difference in measurement is greater or less than 0.4 inch, the vane may be rotated either clockwise or counterclockwise until the required difference of 0.4 inch is obtained.

Bomb Fuzes AN-M101A2, AN-M100A2, and AN-M102A2 are exactly the same as the A1 modification of the corresponding size, but do not require being partially armed. These fuzes arm within minimum combat altitudes. An additional change was the modification of the arming vane assembly from eight blades to four blades in order to make the assembly more stable.

FUZE, Tail, M113.

General. This is an arming vane type of fuze which is used in the 500- and 600-pound GP bombs and M-series demolition bombs. 500-pound SAP bombs also utilize this fuze. It is used for low-altitude land and sea bombing. Its action on impact depends on the action of the primer detonator used. The M16 Primer Detonator has two possible actions, a 4- to 5-second delay for low-altitude sea bombing, and an 8- to 11-second delay for low-altitude land bombing.

The arming time is about 18 turns of the arming vane or 100 feet of air travel. At speeds of 68 miles an hour, the fuze arms approximately 16 feet below the plane. At speeds of 136 miles per hour, the fuze. It has 4 blades, 0.5 inch wide and 5 inches long.

Description. This fuze is similar in outward appearance to Bomb Fuze AN-M101A2, except that it does not have the reduction gear assembly in the head and the cotter pin through the body. As shipped, the Primer Detonator M16, 8- to 11-second delay, is assembled to the fuze. This may be replaced in the field with Primer Detonator

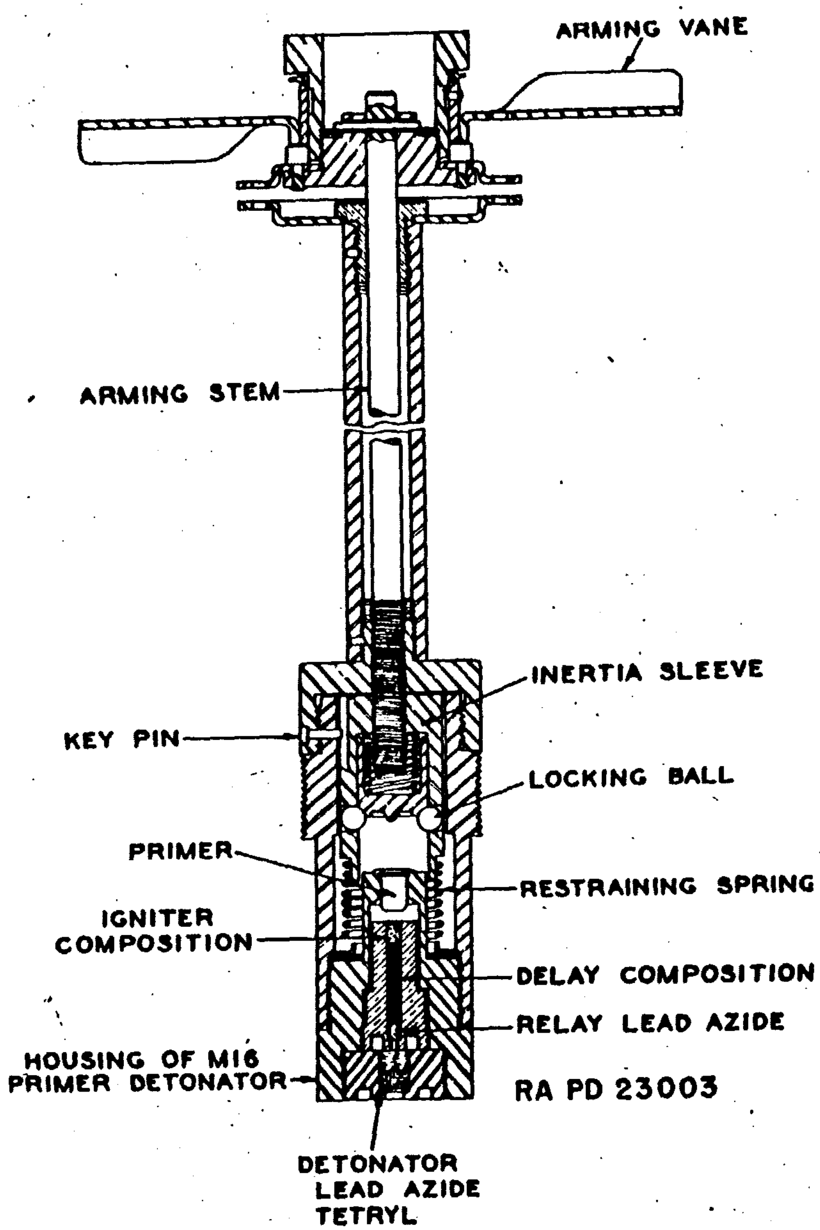


Figure 234 — FUZE, Bomb, M113 (Tail)

M16, 4- to 5-second delay, by unscrewing the primer detonator (which appears as a knurled and grooved member at the forward end of the fuze), and by screwing in the primer detonator assembly with the desired delay. The delay time is marked on the end of the detonator assembly. This replacement is done by hand. The use of tools is neither necessary nor permitted.

Housed in the fuze body, in addition to the detonator assembly, is the firing pin assembly. The firing pin assembly is of the cocked firing pin type. After arming, only a very light impact is necessary to cause detonation of the fuze; therefore, it is extremely sensitive to shock after the fuze is armed. The firing pin assembly is held in place (unarmed) by the threaded arming stem, which passes through the arming stem tube to the upper portion of the fuze. There is no gear reduction mechanism; the arming vane is directly connected to the arming stem which releases the firing pin assembly after approximately 18 turns of the vane. The vane is shipped unassembled to the fuze. It has 4 blades, 0.5 inch wide and 5 inches long.

This fuze is used for low-altitude demolition bombing as its special purpose. For that reason, it is instantaneous in arming and has a long delay action on impact. This long delay allows the plane to escape after the bomb strikes its target, or if it should accidentally strike another bomb while in flight after it has armed. For sea bombing, a 4- to 5-second delay primer detonator is used to allow the bomb to sink a sufficient depth underneath the water and then function near the side of the ship below the water line so as to produce effective damage.

With a direct arming vane type of fuze such as this, a special precaution must be taken to insure that a safety pin or arming wire is in place at all times to prevent any rotation of the vane and arming stem. If the arming stem has been rotated and unscrewed from the firing pin assembly (indicated by a gap between the eyelets in the stem cup and vane holder assembly of ½ inch or more), the fuze should be destroyed. One must not attempt to reengage the threads in the firing pin assembly. If the arming vane and arming stem have rotated, and the gap between eyelets is less than ½ inch, the primer detonator should be removed and the arming stem turned counterclockwise until tight and then turned clockwise three-quarters of a turn. The primer detonator may then be replaced. The arming stem should not be turned while the fuze is in a bomb.

Function. The bomb is dropped and the arming wire is retained in the plane. The arming vane is rotated by the air stream. The rotating arming vane directly connected to the arming stem, unscrews the arming stem from an inertia sleeve, arming the fuze. On impact, the force of inertia causes the inertia sleeve to move inward against a restraining spring. A pair of locking balls housed in the inertia sleeve, and supporting the firing pin, move with the sleeve until they fall into a recess in the fuze housing. The movement of the locking balls into the recess frees the firing pin which is forced into the primer of the M16 Primer Detonator by a compressed spring. The flame produced ignites a black powder igniter charge which in turn ignites a delay of black powder. This burns for 8 to 11 seconds or 4 to 5 seconds, and ignites a relay of lead azide. The wave from the relay functions the detonator of lead azide and tetryl.

Primer Detonator M16. The Primer Detonator M16 screws into the bases of the following Tail Fuzes M112, M113, M114, M115, M116, M117, and M122. The primer detonator consists of a housing so threaded and machined as to receive primer, delay, and detonator assemblies. Around the outside of the housing will be found threads which are designed to screw into the base of any of the fuzes previously mentioned. The M16 Primer Detonator in outward appearance resembles the M14 Primer Detonator. It can be distinguished from the M14 by an annular groove in the knurled part, the base of the M14 being completely knurled for facility in handling. The base is painted yellow with black stencil either 4 to 5 or 8 to 11 seconds, to indicate the time of delay. However, as an added safeguard, the two are so threaded and constructed that it is impossible to interchange the M14 and M16 Primer Detonators. The explosive train consists of the following elements in position as listed:

Primer
Igniter, black powder
Delay, black powder, 4 to 5 or 8 to 11 second
Delay, lead azide
Upper detonator, lead azide
Lower detonator, tetryl

FUZES, Tail, M112 and M114. These fuzes are entirely the same as the M113 described above as far as the description and function are concerned, except for the length of the arming stem fuze. The length of the stems varies so that the arming vane will be properly positioned in the air streams. The arming stems are: 9.6 inches on the M112; 12.6 inches on the M113; and 16.6 inches on the M114. Longer stems are necessary on larger bombs.

FUZES, Tail, M115, M116, and M117. The M115, M116, and M117 are Army fuzes designed for Navy use only. Navy planes leaving from aircraft carriers have found it extremely dangerous to carry bombs fuzed with the M112, M113, or M114 Fuzes because of landing hazards due to their almost instantaneous arming. The M115, M116, and M117 incorporate the reduction gear assembly and arming stem found in the A2 modifications of the AN-M100, AN-M101, and AN-M102 Fuzes. (These fuzes do not have to be partially armed for low-altitude water bombing.) Because of the low altitudes from

which the M115, M116, and M117 Fuzes are dropped, the base incorporates the firing mechanism of the M112, M113, and M114 Fuzes respectively, including the use of the M16 Primer Detonator, 4- to 5- or 8- to 11-second delay. These fuzes can therefore be classified as the arming vane type with mechanical delay with 4- to 5- or 8- to 11-second delay action on impact. The M115 corresponds to the M112 or AN-M100A2 Fuzes in size; the M116 corresponds to the M113 or AN-101A2 in size; the M117 corresponds to the M114 or AN-102A2 in size. The M115, M116, and M117 Fuzes are used in the same size bombs as the respective bomb fuzes to which they correspond.

FUZES, Nose, M118 and M119. These fuzes are of the arming vane type and are used in GP bombs and M-series demolition bombs from 100 to 2,000 pounds, inclusive. 500-pound and 1,000-pound SAP bombs also utilize these fuzes. They are used for low-altitude land and sea bombing. Their action on impact is as follows: M118, 4- to 5-second delay; M119, 8- to 11-second delay. The arming time is approximately 16 turns of the arming vane. This is normally accomplished in 80 to 100 feet of air travel.

Description. The M118 and M119 Bomb Fuzes are quick arming fuzes which may be used for extremely low-altitude bombing against unarmored or lightly armored targets. They contain delay elements which give a time delay of 4 to 5 seconds for the M118 Fuze and 8 to 11 seconds for the M119 Fuze to provide time for the plane to leave the effective area of the bomb blast. The delay element provides the only difference between the two models. The fuzes are intended for special tactical missions as auxiliary fuzes in bombs in which M112, M113, and M114 Tail Fuzes are used. They are similar in appearance to the M103 and AN-M103 Nose Bomb Fuzes, differing in that they do not have the reduction gear assembly in the head, nor do they have instantaneous elements. They are not detonator safe, for the explosive train is always in line whether the fuze is in the armed or unarmed position.

Rotation of the arming vane unscrews the arming screw from the striker, causing the vane cup to move forward and permitting the fuze to arm in a manner similar to the arming of the AN-M103 Fuze. Arming discs between the striker and body of the fuze prevent movement of the striker and firing pin prior to arming. The arming vane is held in position by a spring vane-holder ring. It is shipped unassembled to the fuze. Eyelets in the vane strap which aline with corresponding eyelets attached to the vane cup are provided for the arming wire.

Incorporated in each fuze is the explosive element consisting of primer, igniter, delay, relay, upper and lower detonator, lead charge, and booster charge. The tail fuzes used in conjunction with these nose fuzes may have primer detonators of either 4- to 5-second or

8- to 11-second delay. It is important to use the nose fuze of which the time delay corresponds with the time delay of the primer detonator used in the tail fuze.

Function. The bomb is released and the arming wire is retained in the plane. The arming vane is rotated by the air stream and since it is directly connected to the arming screw it turns the screw up and out of the striker. As the arming screw turns in the striker, it moves the vane cup forward and uncovers the arming discs which are then ejected by a spring. The fuze is now armed, the striker which carries the firing pin being prevented by a shear wire from moving inward.

Upon impact, the striker is forced inward causing the shear wire to be broken and the firing pin to strike the primer. The flame from the primer ignites an igniter of red lead and silicon which in turn functions the delay of lead chromate and silicon of either 4 to 5 seconds (M118 Fuze) of 8 to 11 seconds (M119 Fuze). The flame from the delay ignites a relay charge of lead azide which detonates and sends a wave to the detonator (upper and lower) of lead azide and tetryl. The wave is then carried to a lead charge of tetryl which in turn functions the booster of tetryl, which is a part of the fuze.

FUZE, Tail, M106. This fuze is of the arming pin type and is used in GP bombs and M-series demolition bombs from 100 to 2,000 pounds, inclusive. This fuze is standard for issue only, and was used for low-altitude land demolition bombing. On impact, it has a minimum delay of 45 seconds, and it arms instantaneously. It is 9.4 inches long and weighs 2.38 pounds. It is packed one per fiber container, 50 per box.

Description. The primer, delay element, and detonator are located in the body of the fuze. The delay of 45 seconds in this fuze is obtained by means of a coiled length of safety fuse incorporated in the explosive train between the primer and detonator. The striker is located in the tail end of the fuze and is restrained from moving by the arming pin. A restraining spring between the firing pin and primer prevents the striker, which incorporates the firing pin, from moving forward and resting on the primer after the arming pin has been ejected. The arming pin has two holes, the outer one for a cotter pin for shipment, the inner one, which is visible only when a slight pressure is exerted on the head of the arming pin, for the arming wire. The entire fuze is unpainted.

Function. The bomb is dropped and the arming wire is retained in the plane. The arming pin is ejected by the arming pin spring, arming the fuze. The striker which was held in place by the arming pin is now free and is prevented from resting upon the primer by a restraining spring.

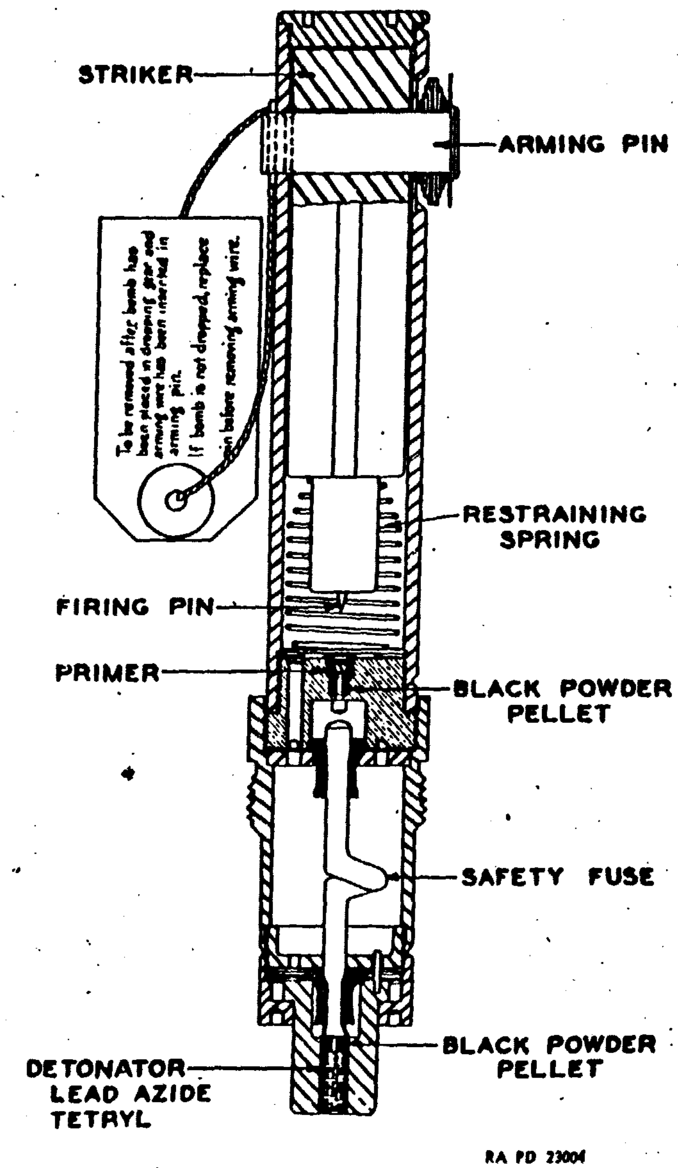


Figure 235 — FUZE, Bomb, M106A1 (Tail)

Upon impact, the force of inertia causes the striker to move inward against the spring driving the firing pin into the primer. The flame from the primer ignites a black powder pellet which insures ignition of the safety fuse. The safety fuse burns from 45 to 60 seconds, at the end of which time, it ignites a second black powder pellet which insures functioning of the detonator of lead azide and tetryl. Upon detonating, the detonator starts a shattering wave which functions the bomb.

Special features of the M106. The M106, besides insuring function of the bomb in the event that the nose fuze fails, is also a special purpose fuze. It is used for low-altitude land demolition bombing. When used for this purpose, the nose fuze is made inoperative by removal of the arming vane or by wrapping the arming wire around the vane, or by removing the nose fuze entirely. Because it is dropped from low altitudes, it arms instantaneously and has a long delay in action on impact to allow the pilot and plane to escape. From low altitudes, the force of inertia is not great. To insure the fuze's functioning, the M106 has a very heavy striker or plunger, a light restraining spring, and a very sensitive primer.

It was found in low-altitude bombing that the angle of impact of the bomb body was almost flat on its side. This tended to break the tail fuze at the point of entrance into the bomb case or rip it entirely out of the bomb body. This led to failure of the bomb to function. An improvement was made to overcome this difficulty. The M106 Fuze body was weakened by machining a groove somewhat above the external threads designed to screw into the bomb body. When the fuze does snap off, having this groove it will break at that point where the complete function will not be hindered.

M106A1. The A1 modification consists of reducing the action of impact from a minimum of 45 seconds to 8 to 11 seconds. In all other features, the fuze is entirely the same. The time of delay and the fuze model is indicated by black stencil on the side of the fuze housing, and the outer end of the body is painted white with the top painted green.

M106A2. For sea bombing, 8- to 11-second delay is too long. The A2 modification consists of reducing the action of impact from 8 to 11 seconds to 4 to 5 seconds. In all other features, the fuze is entirely the same as the M106 and M106A1. The time of delay and fuze model is indicated by black stencil on the side of the fuze housing and the outer end of the body is painted white with the top painted yellow.

The M106 with the A1 and A2 modifications is standard for issue only. The M112, M113, and M114 Fuzes as previously described were designed to replace the M106, M106A1, and M106A2 and were found much more satisfactory.

FUZE, Tail, M122.

General. This fuze is of the arming vane type with mechanical delay. In outward appearance and size, it resembles the M102 Bomb Fuze, having the same reduction gear train. It has, however, the cocked firing pin assembly of the M114 Bomb Fuze. It is a combination, therefore, of two fuzes previously discussed. The primer detonator is the M16 which has been previously described. It is used on a modified 2,000-pound GP bomb in conjunction with the M121 and M4 Destructor which destroys the control units of the bomb. No further information is available at the present time.

FUZE, Tail, M124.

General. This fuze is a very long delay fuze. It functions from 1 hour to 6 days after impact. It has an ampoule of acetone which is crushed by the arming stem. The acetone dissolves a celluloid collar which supports a firing pin. In size, it resembles the M101. It has incorporated in the fuze an antihandling device which will function the fuze if an attempt is made to unscrew it from the bomb body.

This fuze is used on the 500-pound GP bomb, all models; the 500-pound SAP bomb, and the 600-pound demolition bomb which preceded the GP bombs. It is designed to make immediate reparation of enemy targets that have been bombed extremely hazardous. It is further designed to provide a demoralizing effect since it will function if any attempt is made to remove it.

NOTES: Changes in fuze temperature will cause the average delay time to vary approximately as follows:

Temperature (Degrees F)	Average Time (6-hour Delay) (Hours)
110	1
75	2
45	4
40	6
25	12

The firing pin in the fuze is supported by a celluloid collar which may be damaged by exposure to high temperature. If the temperature exceeds 150 F (as indicated by solidification of powder in a green stoppered vial in the packing box), the fuze must not be used for low-altitude bombing. If the temperature exceeds 170 F (as indicated by solidification of powder in a red stoppered vial), the fuze must be destroyed.

Since the glass ampoule in this fuze may break on impact, with subsequent functioning, the fuze must be treated as though it cannot be dropped "safe."

Assembling the fuze to a bomb.

1. Remove adhesive tape and shipping plug from detonator end of fuze. In so doing the fuze should be held by body extension and not by body.

2. Insert holder closing disc (aluminum or copper); holder sealing washer (lead); and detonator holder assembly in lower end of fuze. These parts are packed in the wooden block inclosed with each fuze. Tighten detonator holder assembly with wrench. Since the purpose of the holder closing disc and sealing washer is to seal the detonator against the liquid contents of the fuze, considerable torque should be used to assure proper sealing of the detonator holder assembly. When properly assembled, the holder sealing washer will be flattened and deformed to a considerable extent. In making this assembly, special care should be taken that the crimp holding the extension ball in place is not damaged.

3. Remove thumb screw and ball clip. Ball should move freely in groove. After thumb screw has been removed, every effort should be made to handle fuze carefully since this fuze will fire if body extension is backed off approximately $\frac{3}{64}$ inch from the body.

4. After making sure ball will move freely in groove, screw fuze in bomb as far as possible. *Fuze must not be unscrewed during or after assembly to bomb since unscrewing will cause ball to seize in adapter and will cause fuze to fire.*

5. Arming wire should be inserted in place of arming block cotter pin before safety pin is removed. Fuze is to be inserted in bomb immediately before aircraft takes off. *Fuzed bombs must never be stored.*

FUZES, Tail, M123 and M125. These fuzes are exactly the same as the M124, differing only in the size of the arming stem tube and bombs for which they are adapted in the same manner as the M100, M101, and M102.

FUZE, Tail, Hydrostatic, AN-Mk. 230.

General. This is an arming vane type of fuze with a mechanical delay. Upon arming, detents (spring actuated pins) fly out so as to allow a bellows-like affair to expand under water pressure. It can function in various prechosen depths, and settings are made by a dial located on the exterior of the fuze body which operates a spindle inside the bomb fuze. The spindle varies the compression on the depth spring. By turning the dial, one of five settings can be obtained; namely, 25-, 50-, 75-, 125-, and 175-foot depths.

In operation, it is somewhat similar to the AN-Mk. 224 discussed later in the text except that water pressure forces the initiating explosive into a stationary firing pin. Only one system of bellows is used.

The fuze is used on 500-pound AN-M64 GP, 1,000-pound AN-M65 GP, and 2,000-pound AN-M66 GP Bombs in conjunction with the M115 Adapter Booster. When using this fuze, the sleeve in the M115 Adapter Booster must be removed so that the fuze can be screwed directly into the adapter booster.

Bombs fuzed with the AN-Mk. 230 Fuze are designed to be used against submarines.

Inspection of Bomb Components.

Bomb body. The bomb body should be inspected for proper painting and stenciling, rust spots, and for bent or broken areas. The shipping plugs should be removed from the fuze cavities and the cavities should be inspected for cleanliness and for worn or battered threads. The threads may be gaged for the purpose of insuring free entrance of the fuzes. The fin lock nut should be present and should be held in place securely, when the fin is unassembled, by cotter pins or wires.

Metal shipping bands, when present, should be inspected to insure that they are firmly attached and that the cotter pin which holds one of the main bolts in place has its ends spread apart wide enough so that it will not fall out. The nut holding the second bolt should be screwed on securely. Paper shipping bands, when present, should be inspected to make sure that they are firmly attached. The cotter pin which holds the retainer pin in position should be spread wide apart. The steel strip which holds the shoe around the paper band should be so tightened as to allow the shoe to fit securely over the paper band.

Suspension lugs should be checked for strength of welds to the bomb body and for any damage which might result in weakened lugs. They should be gaged by use of a bomb shackle to insure that they are the correct distance apart and in alinement with each other.

Fuzes. The container should be examined to insure that it is not damaged and is properly stenciled. The fuze should be free from any deterioration such as heavy rust or corrosion which might interfere with the proper function of the fuze and it should be free from any damage due to rough handling. Cotter pins should be checked for sufficient spread and for rust or corrosion which would make withdrawal difficult. All springs should be examined to make sure that rust, corrosion, or brittleness does not interfere with their proper function. In so far as possible, it should be ascertained that all visible safety components such as arming pins, safety blocks, cotter pins, and set screws are present. Fuze threads, external and internal, if present, should be examined to insure that they are not battered, rusted, worn or burred. Vanes should not be damaged nor distorted.

Arming wire assembly. This should be examined to insure that the wire is free from kinks, burs, or rough spots. The swivel loop

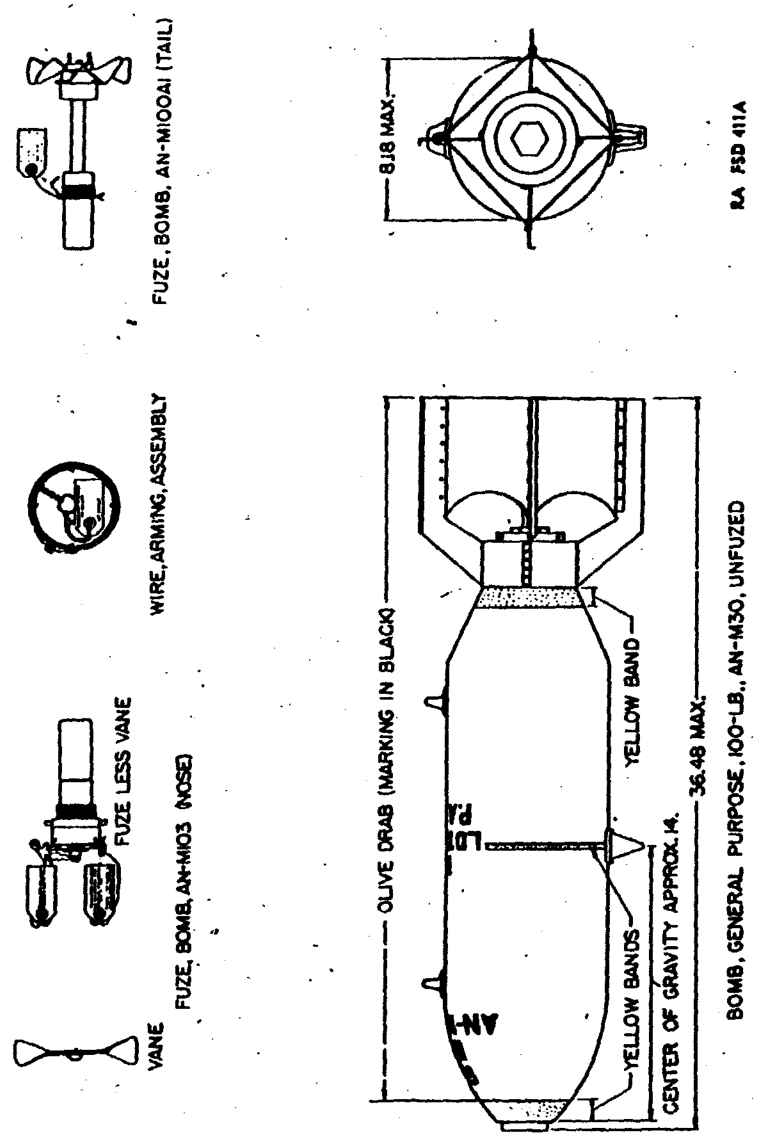


Figure 236 — BOMB, G.P., 100-pound Components, Complete Round

should be properly assembled and should be securely fastened. The arming wire must be checked for brittleness by gripping the ends and bending in a gentle loop, taking care not to produce kinks. The wire must be the proper type, thickness, length, and all additional components to make the assembly complete must be present. When assembled to the bomb, the arming wire should protrude from the fuze housing approximately 2½ inches.

Fin assembly. The fin assembly must be inspected for any distortion or damage. It should be properly welded and painted. If the fin assembly is attached to the bomb, it should be assembled securely and should be so alined that one blade will be in exact line with the suspension lugs, or at an angle of 45 degrees with the lugs. If the fin assembly is not attached to the bomb body, it should be in its proper metal crate. In the crate should be all the necessary components that travel with the fin for that particular assembly. The crate should be properly painted and stenciled.

Inspection Areas. An inspection such as the above in which the components are broken out of the packing should be carried on at a safe distance taking into consideration various factors in accordance with Ordnance Safety Manual regulations.

BOMB, GENERAL PURPOSE, 100-POUND, AN-M30.

General. The GP and M-series bombs of 100-pound weight have the same dimensions. The GP is distinguishable from the M-series by the fact that it has a base plug in the tail and a single suspension lug in addition to two Army lugs. The two Army lugs are 14 inches apart, each 7 inches away from the center of gravity. The single suspension lug is on the center of gravity 14 inches behind the nose.

Use. The 100-pound bomb is used on such targets as ammunition dumps, railway rolling stock, ordinary buildings, supply depots, grounded planes, and aircraft installations.

Description. The total length of this bomb is 38.5 inches, and the diameter is 8.2 inches. The weight of the case is 42.1 pounds and the fins weigh 3.5 pounds. The filler is either 53.3 pounds of 50/50 amatol or 56.6 pounds of TNT. The total weight of the bomb filled with amatol is 98 pounds, and if filled with TNT it weighs 100 pounds. Percentage of filler is approximately 49 percent.

Fuzes. The AN-M30 Bomb is fuzed in the nose with the AN-M103 Fuze and in the tail with the AN-M100A2 Fuze. Alternate fuzes that may be used as substitutes or for special purposes are the M103, M118, or M119 Nose Fuzes, and the M112, M100, M106, or its modifications, or the AN-M100A1 Tail Fuzes.

Complete Round Components. A complete round consists of the following components or an alternate if permissible:

Loaded AN-M30, GP, 100-pound Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M100A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, GENERAL PURPOSE, 250-POUND, AN-M57.

General. The 250-pound bomb replaced the 300 pound, and is preferred when available. The AN-M57 has a base plug in the tail, the single suspension lug, and the two Army suspension lugs. The Army lugs are 14 inches apart, each 7 inches from the center of gravity. The single suspension lug is on the center of gravity 17.7 inches behind the nose.

Use. Targets suitable for the 250-pound bomb are concentrations of railway rolling stock, rail terminals and buildings of similar construction, ammunition dumps, aircraft installations, seacraft such as submarines, transports, destroyers, etc.

Description. The total length of this bomb is 47.8 inches and the diameter is 10.9 inches. The weight of the case is 116. 6 pounds and the fins weigh 6.0 pounds. The filler is either 123.7 pounds of 50/50 amatol or 129 pounds of TNT. The total weight of the bomb filled with amatol is 240.9 pounds and if filled with TNT it weighs 262.3 pounds. Percentage of filler is approximately 49 percent.

Fuzes. The 250-pound Bomb AN-M57 is fuzed in the nose with the AN-M103 Fuze and in the tail with the AN-M100A2. Alternates or substitutes are exactly as those provided for the 100-pound AN-M30 Bomb described previously.

Complete Round Components. A complete round consists of the following listed components or permissible alternates:

Loaded AN-M57, GP, Bomb Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M100A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, GENERAL PURPOSE, 500-POUND, AN-M43 AND AN-M64.

General. The 500-pound bomb is made in three models: the M43, the AN-M43, and the AN-M64. The case and the fin can be considered the same for the three models; therefore, these bombs are con-

sidered under one heading because of their similarity in construction and use.

The identifying features of the M43 are the tail-base cap and two Army suspension lugs. This bomb is converted for Navy use by the M1 Trunnion Band which is shipped as an accessory. The AN-M43 has the same case as the M43, but is readily identifiable by the tail-base plug and the addition of the single suspension lug.

The AN-M64 is practically the same bomb as the AN-M43 having a tail-base plug. The internal threads are somewhat wider in diameter to receive the M115 Adapter Booster, which results in a slight change in the fin assembly. It also has two Army suspension lugs and the single lug. One distinguishing feature is the presence of a sleeve in the tail adapter booster for Army tail fuzes. The AN-M64, by utilizing the M115 Adapter Booster, makes it possible to use both Army and Navy tail fuzes. The diameter of the Navy fuze is greater than that of the Army fuze and therefore requires an adapter of larger dimensions. To reduce the diameter of the adapter to take the Army fuzes, a threaded sleeve is screwed into the M115 Adapter Booster. Bombs using the M115 Adapter Booster are shipped with the sleeve in place. To make use of the Navy fuze, the sleeve must be removed with a special stud wrench having two studs which fit into the two holes in the face of the sleeve.

Use. These bombs are intended for destructive effect against such targets as steel railway bridges, underground railways, seacraft such as light cruisers, concrete docks, medium size buildings, etc.

Description. The total length of these bombs is 59.2 inches, and the diameter is 14.2 inches. The case is 0.3 inch thick and weighs 210 pounds. The explosive filler is either 264.5 pounds of 50/50 amatol or 280 pounds of TNT. The total weight when filled with amatol is 494 pounds, and if filled with TNT the weight is 508 pounds.

Fuzes. The standard nose fuze used in these bombs is the AN-M103 and the tail fuze is the AN-M101A2. Alternates or substitutes are the M103, M118, or M119 Nose Fuzes and the M113, AN-M101A1, M101, M106 (all modifications), or the AN-Mk. 230 Hydrostatic Tail Fuzes.

Complete Round Components. A complete round consists of the following components or their substitutes:

Loaded M43, AN-M43, or AN-M64 Bomb Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M101A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, GENERAL PURPOSE, 1,000-POUND, AN-M44 AND AN-M65.

General. The 1,000-pound bomb is made in three models, the M44, the AN-M44, and the AN-M65. The bomb case and the fin can be considered the same for the three models; therefore, these bombs are considered under one heading because of their similarity in construction and use.

The M44 is identified by the tail-base cap and the two Army suspension lugs. It is converted to Navy use by the M2 Trunnion Band. The AN-M44 makes use of the same case as the M43 but is readily identifiable by the tail-base plug and the addition of the single suspension lug. The AN-M65 is distinguished from the AN-M44 by the sleeve in the M115 Adapter Booster. The M115 Adapter Booster is used to adapt both Army and Navy tail fuzes. The sleeve must be removed when Navy fuze is used. Detailed explanation of the M115 Adapter Booster is given under the AN-M64 500-pound Bomb.

Use. These bombs are intended for destructive effort aganst such targets as reinforced concrete bridges, steel railway bridges, piers, approach spans, etc.

Description. The total length of these bombs is 69.5 inches and the diameter is 18.8 inches. The case is 0.35 inch thick and weighs 399 pounds. The fins weigh 21.5 pounds. The filler is 536.6 pounds of 50/50 amatol or 566 pounds of TNT. The total weight is 939 pounds when loaded with amatol, and 967 pounds when loaded with TNT. Percentage of filler is 56 percent.

Fuzes. These bombs are fuzed with the AN-M103 Nose Fuze and the AN-M102A2 Tail Fuze. Alternate or substitute fuzes are the Nose Fuzes M103, M118, or M119, and Tail Fuzes AN-M102A1, M114, M106 (all modifications), M102, or the AN-Mk. 230 Hydrostatic Fuze.

Complete Round Components. A complete round includes the following components or any permissible alternates:

Loaded M44, AN-M44, AN-M65 Bomb Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, GENERAL PURPOSE, 2,000-POUND, AN-M34 AND AN-M66.

General. The 2,000-pound bomb is made in three models: the M34, the AN-M34, and the AN-M66. The bomb case and the fin

assembly can be considered the same for the three models; therefore, these bombs are considered under one heading because of their similarity in construction and use.

The M34 is identified by the tail-base cap and two Army suspension lugs. The suspension lugs are 30 inches apart. The AN-M34 has the additional single suspension lug and the tail-base plug. The single lug is on the center of gravity 33.5 inches behind the nose. The AN-M66 can be distinguished by the M115 Adapter Booster, used to adapt Navy fuzes to Army bombs.

Use. These bombs are intended for destructive effect against such massive structures as reinforced concrete bridges, dams, battleships, large skyscrapers, etc.

Description. These bombs are 92.9 inches long with a diameter of 23.3 inches. The case is 0.52 inch thick and weighs 942.5 pounds. The explosive filler is 1,014 pounds of 50/50 amatol or 1,117 pounds of TNT. The total weight is 2,045 pounds if filled with amatol, and 2,101 pounds if filled with TNT. Percentage of explosive filler is 54 percent.

Fuzes. These 2,000-pound bombs are fuzed in the nose with the AN-M103 Fuze, and in the tail with the AN-M102A2 Fuze. Alternates or substitutes for the nose are the M103, M118, or M119 Fuze. Alternate fuzes for the tail are the AN-M102A1, M106 (all modifications), M102, M114, or the AN-Mk. 230 hydrostatic.

Complete Round Components. A complete round consists of the following components or their alternates:

Loaded M34, AN-M34, AN-M66 Bomb Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, LIGHT CASE, 4,000-POUND, AN-M56.

General. This bomb is designated as a light case because it has an exceptionally thin metal case in order to allow for a high percentage of explosive filler. Because of the equipment required to carry and release this bomb, it has only two Army suspension lugs 30 inches apart. Contrary to the other modern bombs previously described, the tail end is closed with a rear closing cap instead of a tail-base plug. This is due to the fact that penetration is not

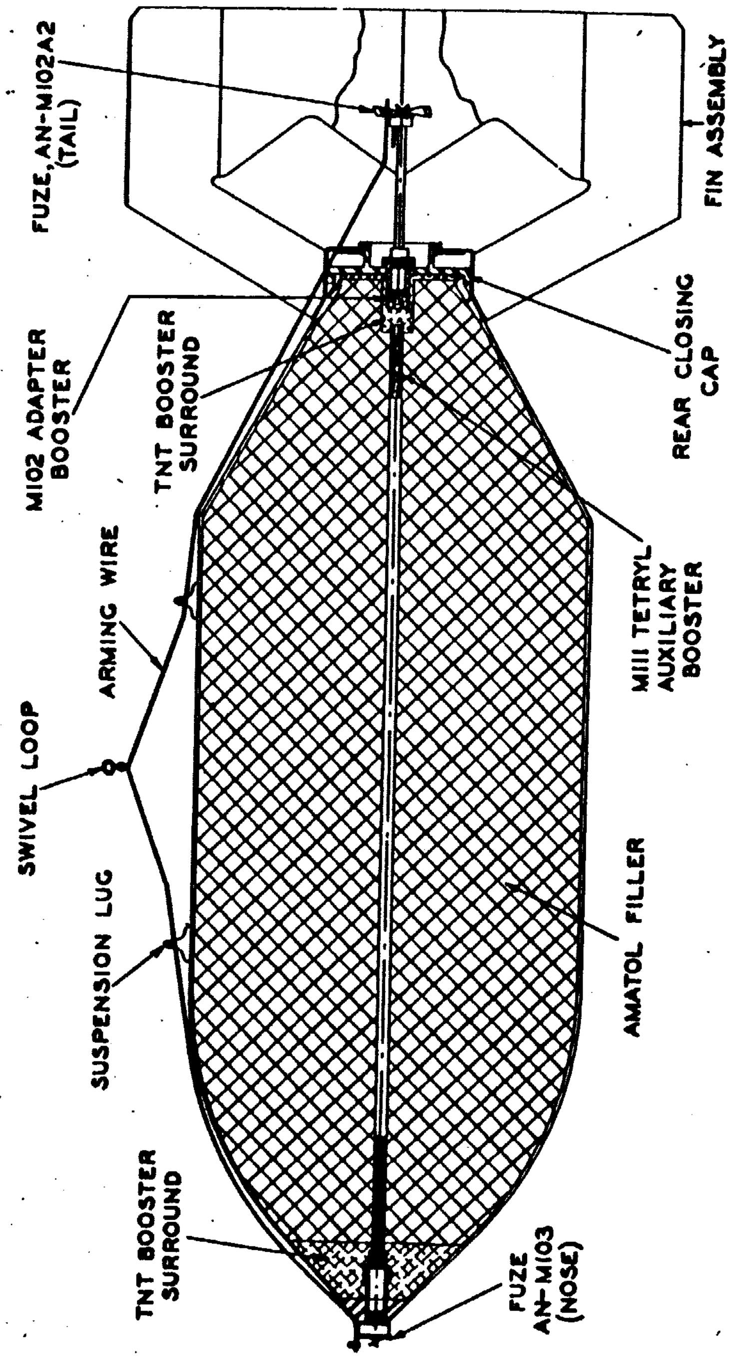


Figure 237 — BOMB, Light Case, 4,000-pound, AN-M56

desired. This is the largest bomb used by the U. S. forces today, although larger bombs may be forthcoming as the need arises.

Use. This bomb is intended for use against targets of large area such as villages, towns, and cities to produce a tremendous blast effect. It is familiarly termed a block buster.

Description. The total length of this bomb is 117.2 inches, and the diameter is 34.2 inches. The case is 0.38 inch thick and weighs 840.3 pounds. It is filled with either 3,240.6 pounds of 50/50 amatol, or 3,362 pounds of TNT. The total loaded weight is 4,087 pounds if filled with amatol, or 4,204 pounds if filled with TNT. Percentage of filler is 77.4 percent.

Fuzes. The L.C. 4,000-pound bomb is fuzed with the AN-M103 in the nose and the AN-M102A2 nondelay in the tail. Alternates are the M103 Nose Fuze and the AN-M102A1 Tail Fuze.

Complete Round Components. A complete round is made up of the following components:

Bomb Case AN-M56, loaded (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M102A2, nondelay (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, DEMOLITION, 300-POUND, M31.

General. The 300-pound M31 Bomb has been replaced by the 250-pound bomb, but it is still found in service. It is identified by the rear closing cap and it has only two Army suspension lugs 14 inches apart.

Use. It is used on the same targets as the 250-pound GP bomb previously described. These targets are concentrations of railway rolling stock, brick and concrete buildings, aircraft installations, supply depots, and unarmored seacraft.

Description. The length of the 300-pound demolition bomb is 51 inches and its diameter is 10.9 inches. The case is 0.2 inch thick and it weighs 124 pounds. The explosive filler consists of 135 pounds of 50/50 amatol, or 144 pounds of TNT. Total weight of the bomb is 263 pounds when loaded with 50/50 amatol, and 270 pounds when loaded with TNT. The percentage of explosive filler is 50 percent.

Fuzes. The 300-pound Bomb M31 is fuzed with the Nose Fuze AN-M103 and the Tail Fuze AN-M100A2. Alternate fuzes are the M103, M118, or M119 Nose Fuzes and the M112, M100, AN-M100A1, or M106 (all modifications) Tail Fuzes.

Complete Round Components. A complete round consists of the following components or their alternates:

Loaded M31 Bomb Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M100A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, DEMOLITION, 600-POUND, M32.

General. The 600-pound bomb has been superseded by the 500-pound GP bomb. It is identified by the presence of two Army lugs and a rear closing cap.

Use. It is used on the same targets as the 500-pound GP bombs previously described. These targets are light steel bridges, concrete docks, underground railways, medium sized buildings, light cruisers, seacraft, and railway terminals.

Description. This bomb has a total length of 61.9 inches and has a diameter of 15.2 inches. The case is 0.35 inch thick and weighs 265.5 pounds. It has an explosive filler of 319.3 pounds of 50/50 amatol, or 336 pounds of TNT. Total weight of the bomb filled with amatol is 586 pounds, and if filled with TNT, it weighs 603.5 pounds. The percentage of explosive filler is approximately 56 percent.

Fuzes. The nose fuze used in the 600-pound bomb is the AN-M103 and the tail fuze is the AN-M101A2. Permissible alternates are the M103, M118, and M119 Nose Fuzes as well as the M113, M101, AN-M101A1, and M106 (all modifications) Tail Fuzes.

Complete Round Components. A complete round consists of the following components or their permissible components:

Loaded M32 Bomb Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M101A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, DEMOLITION, 1,100-POUND, M33.

General. The 1,100-pound bomb has been replaced by the 1,000-pound GP bomb, but it may still be found in service. It is identified by the rear closing cap and it has only two Army suspension lugs 14 inches apart.

Use. It is used on the same targets as the 1,000-pound GP bombs. These targets are reinforced concrete and heavy steel bridges, large reinforced buildings, light armored seacraft, reinforced docks, and warehouses.

COMPLETE ROUND CHART—GP BOMBS

Weight, Designation, and Status	Weight of Filler (Amatol)	Tail Auxiliary Booster	Tail Adapter Booster	Tail Fuze	Nose Fuze	Nose Auxiliary Booster
100 lb AN-M30 (S&M)	54.2 lb	None	M102	AN-M100A2(1)	AN-M103(2)	M104
250 lb AN-M57 (S&M)	123 lb	M104	M102	AN-M100A2(1)	AN-M103(2)	M104
500 lb AN-M43 (S)	266 lb	M104	M102	AN-M101A2(3)	AN-M103(2)	M104
500 lb AN-M64 (S&M)	264.5 lb	M104	M115	AN-M101A2(4)	AN-M103(2)	M104
1,000 lb AN-M44 (S)	538 lb	M104	M102	AN-M102A2(5)	AN-M103(2)	M104
1,000 lb AN-M65 (S&M)	536.6 lb	M104	M115	AN-M102A2(6)	AN-M103(2)	M104
2,000 lb AN-M34 (S)	1,077 lb	M104	M102	AN-M102A2(5)	AN-M103(2)	M104
2,000 lb AN-M66 (S&M)	1,014 lb	M104	M115	AN-M102A2(6)	AN-M103(2)	M104
4,000 lb AN-M56 L.C. (S&M)	3,245 lb	....	M102	AN-M102A2(7)	AN-M103(8)	M111(9)

(1) Fuze AN-M100A1, M100, M106 or modifications, M112, M115, or M123 may be substituted.
(2) Fuze M103, M118, M119, may be substituted.
(3) Fuze AN-M101A1, M101, M106 or modifications, M113, M116 or M124 may be substituted.
(4) Fuze AN-M101A1, M101, M106 or modifications, M113, M116, M124 or AN-Mk. 230 may be substituted.
(5) Fuze AN-M102A1, M102, M106 or modifications, M114, M117, or M125 may be substituted.
(6) Fuze AN-M102A1, M102, M106 or modifications, M114, M117, M125 or AN-Mk. 230 may be substituted.
(7) Fuze AN-M102A1 may be substituted.
(8) Fuze M103 may be substituted.
(9) Passes through entire length of bomb body from nose to tail.

FUZES USED IN GP BOMBS

Fuze Designation	Position in Bomb	Booster in Fuze	Bomb for Which It Is Adapted	Method of Arming	Primer Detonator	Action on Impact
M100	Tail	No	100 to 300 lb	Arming Vane w/mech. del.	None	0.1 sec del.
AN-M101A1	Tail	No.	500 and 600 lb	Arming Vane w/mech. del.	M14 or M14A1	Nondelay to 0.1 sec del.
AN-M102A2	Tail	No	1,000 to 4,000 lb	Arming Vane w/mech. del.	M14 or M14A1	Nondelay to 0.1 sec del.
AN-M103	Nose	Yes	All GP Incl. 4,000 lb L.C.	Arming Vane w/mech. del.	None	Selective Inst., or 0.1
M106	Tail	No	All GP	Arming Pin	None	45 sec del.
M106A1	Tail	No	All GP	Arming Pin	None	8 to 11 sec del.
M106A2	Tail	No	All GP	Arming Pin	None	4 to 5 sec del.
M112	Tail	No	100 to 300 lb	Arming Vane	M16	4 to 5 sec or 8 to 11 sec del.
M113	Tail	No	500 and 600 lb	Arming Vane	M16	4 to 5 sec or 8 to 11 sec del.
M114	Tail	No	1,000 to 2,000 lb	Arming Vane	M16	4 to 5 sec or 8 to 11 sec del.
M115	Tail	No	100 to 300 lb	Arming Vane w/mech. del.	M16	4 to 5 sec or 8 to 11 sec del.
M116	Tail	No	500 and 600 lb	Arming Vane w/mech. del.	M16	4 to 5 sec or 8 to 11 sec del.
M117	Tail	No	1,000 to 2,000 lb	Arming Vane w/mech. del.	M16	4 to 5 sec or 8 to 11 sec del.
M118	Nose	Yes	All GP	Arming Vane	None	4 to 5 sec del.
M119	Nose	Yes	All GP	Arming Vane	None	8 to 11 sec del.
M121	Tail	No	Destructor	Arming Vane w/mech. del.	M27	Nondelay
M122	Tail	No	2,000 lb	Arming Vane w/mech. del.	M16	4 to 5 sec or 8 to 11 sec. del.
M123	Tail	No	100 to 300 lb	....	....	1 to 144 hr del.
M124	Tail	No	500 and 600 lb	....	....	1 to 144 hr del.
M125	Tail	No	1,000 to 2,000 lb	....	....	1 to 144 hr del.
AN-Mk. 230	Tail	No	500, 1,000, 2,000 lb	Arming Vane w/mech. del.	None	Water pressure

Description. This bomb has a total length of 71.1 inches and a diameter of 19.8 inches. The case is 0.43 inch thick and weighs 493.7 pounds. The filler is 588 pounds of 50/50 amatol, or 613 pounds of TNT. The total weight when filled with amatol is 1,083.4 pounds, and when filled with TNT, it weighs 1,113.4 pounds. The percentage of filler is approximately 54 percent.

Fuzes. Fuzes provided for this bomb are the AN-M103 Nose Fuze and the AN-M102A2 Tail Fuze. Alternate fuzes are the M103, M118, or M119 Nose Fuze with the M114, M102, AN-M102A1 or M106 (all modifications) Tail Fuzes.

Complete Round Components. A complete round consists of the following components or permissible alternates:

Loaded M33 Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

DESTRUCTOR M4.

General. The Destructor M4 is a detonating device for use in control unit boxes of certain planes to destroy their contents completely. It consists primarily of an explosive block of 2.5 pounds of tetrytol, an impact type of bomb tail fuze, and accessories for its assembly and mounting in the control unit.

Description. The main destructor assembly consists of an adapter into which the fuze fits, and of the explosive block mounted on a sheet metal support which is bent into the shape of an L. The adapter is welded in place on the short leg of the L. The explosive block is strapped in place on the other leg. The adapter and explosive block are connected by a length of detonating cord, which is crimped to the base of the adapter and extends to and through the center of the explosive block. A wood block having a channel to accommodate the detonator cord is fastened to the support and protects the detonator cord.

Complete Round Components. The Destructor M4 consists of the following components:

Main destructor assembly
Fuze Bomb M121 (tail) with vane assembly
Arming wire assembly
Fuze locking nut

FUZE, Tail, M121 for Destructor. This fuze is of the arming vane type with mechanical delay. It resembles in outward appearance and size, the M100 Bomb Fuze having the same reduction gear train as the M100. It has, however, the cocked firing pin assembly

of the M112 Bomb Fuze. It is a combination, therefore, of two fuzes previously discussed. The primer detonator it has incorporated in it, however, is the M27 Nondelay Primer Detonator which functions immediately on impact. It is used to function the M4 Destructor detonating device. On impact, the detonator in the fuze fires the detonator cord which detonates the explosive block of 2.5 pounds of tetrytol.

FURTHER REFERENCES: All references may be found at the close of this section.

Chapter 3

Semi-armor-piercing and Armor-piercing Bombs

GENERAL.

Semi-armor-piercing Bombs. Semi-armor-piercing (SAP) and armor-piercing (AP) bombs are designed to pierce the deck armor of battleships, heavy concrete structures, and similar highly resistant targets. SAP bombs have a heavy case of special steel and contain approximately 30 percent explosive. They are effective against all but the heaviest deck armor of modern battleships. SAP bombs are conventional in outline, resembling cylindrical GP bombs but being somewhat smaller in diameter and longer. The nose fuze seat liner is generally filled by a steel plug.

Armor-piercing Bombs. Armor-piercing bombs are designed to penetrate the heaviest deck armor, such as that used on the deck of a modern battleship. Unlike the rest of our modern demolition bombs, the armor-piercing bombs are filled with explosive D. This explosive is used because armor-piercing bombs are subject to great shock, and explosive D is very insensitive to shock. Armor-piercing bombs are designed to penetrate the target before function, and premature function due to a sensitive explosive is therefore undesirable.

Both the Navy and Army have a series of armor-piercing bombs. The Army bombs are converted 10-inch, 12-inch and 14-inch seacoast mortar deck-piercing or armor-piercing projectiles. The suspension lugs are attached to the body by means of suspension bands that surround the circumference of the shell and are bolted in place. A tail-base plug has been added to adapt the shell for tail adapter booster, fuze, and fin assembly. These bombs are standard for issue only.

The Navy bombs are made to be interchangeable for Army or Navy use. These bombs are standard for issue and manufacture.

Penetration and Terminal Velocity. GP bombs will penetrate three to four stories of ordinary buildings. SAP bombs will penetrate five to six stories of heavy construction or 2½ to 3 inches of armor plate. AP bombs are made to pierce 6 to 7 inches of armor plate.

The semiarmor-piercing bombs are capable of penetrating moderately armored decks from 12,000-foot altitude in horizontal bombing, or light armored decks in dive bombing from about 2,500-foot altitude. There is a small degree of underwater effect from near misses with the 1,000-pound size, but the effect is negligible with the 500-pound size.

The large armor-piercing bombs are capable of piercing the heaviest armor deck from about 12,000 feet in horizontal bombing, or moderate decks in dive bombing from about 2,500 feet.

In considering the terminal velocity of the above types of bombs, it was found that at 14,000 feet, planes traveling at 200 miles per hour dropped bombs producing the following maximum terminal velocities:

GP	SAP	AP
600-700 ft per sec	750-800 ft per sec	900-950 ft per sec

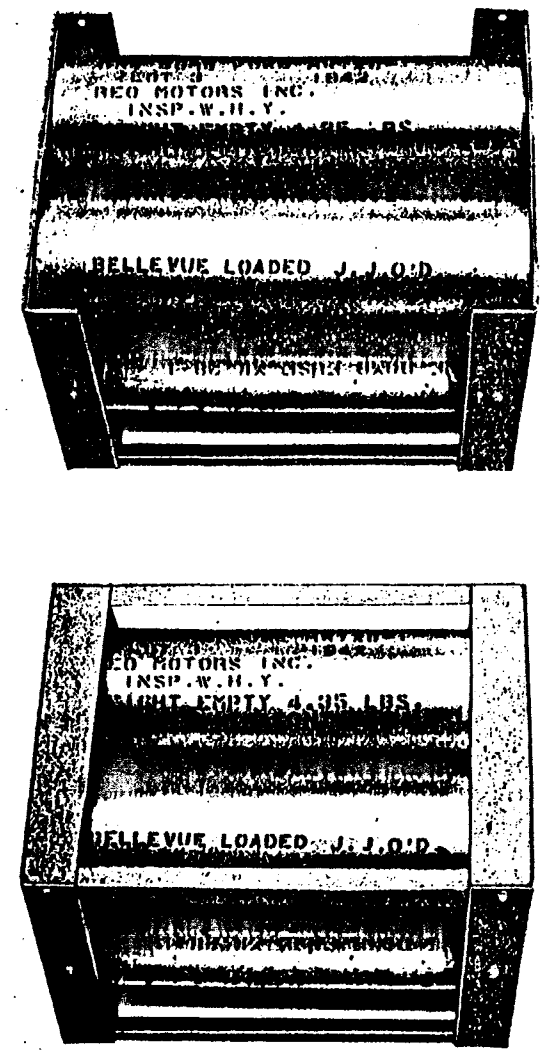
Armor-piercing Bomb Fuze, Nose AN-Mk. 228.

General. This fuze is designed to be used on armor-piercing bombs of Navy design such as the 1,600-pound AN-Mk. 1 and the 1,000-pound AN-Mk. 33. It is of the arming vane type with mechanical delay having a series of reduction gears to produce the desired delay in arming. It arms in 900 feet of air travel, and is designed to function on impact with a delay time of 0.08 second. One auxiliary booster of 180 grams is required to be used with this fuze. The auxiliary booster is found in the adapter booster fuze seat located in the bomb body. The fuze is packed one per can, four cans per crate.

BOMB, SEMI-ARMOR-PIERCING, 500-POUND, AN-M58.

General. This bomb is of the cylindrical type and has a box type fin. It contains approximately 154 pounds of high explosive and is adapted for both nose and tail fuzes, although the nose fuze seat liner contains a steel plug instead of a fuze. The tail-fuze cavity is kept free of foreign matter by means of an adapter plug. This bomb can be identified by the sharply pointed nose and pointed nose plug. It has two Army suspension lugs 14 inches apart and a single suspension lug at the center of gravity. It utilizes a tail-base plug as the GP bombs do.

Use. The 500-pound AN-M58 SAP Bomb is designed to pierce armor plate, reinforced concrete construction, and similar resistant targets.



RA PD 7240

Figure 238 — FUZE, Bomb, AN-Mk. 28, Mod. 1—Packing

Description. The total length of the 500-pound SAP bomb is 57.9 inches and the diameter is 11.9 inches. The case is 0.75 inch thick and weighs 310 pounds. It is filled with 154 pounds of 50/50 amatol, or 159 pounds of TNT. Total filled weight is 466.5 pounds if amatol is used, or 471.5 if TNT is used. The percentage of explosive filler is approximately 32 percent.

Fuzes. Standard fuzes used are, none in the nose and the AN-M101A2 in the tail. For special purposes or as substitutes, Alternate Fuzes M103, AN-M103, M118, and M119 are used in the nose while the AN-M101A1, M101, M113, and M106 (all modifications) are supplied for the tail.

Complete Round Components. The following components are provided to make up a complete round:
Bomb Case AN-M58, loaded (1)
Tail fuze AN-M101A2 (1)
Fin assembly (1)
Arming wire type A (1)
Fahnestock clip (1)

BOMB, SEMI-ARMOR-PIERCING, AN-M58A1.

General. This bomb was designed to replace the AN-M58 which was found to lack necessary penetrating power to be effective.

The AN-M58A1 is the same as the AN-M58 except for a heavier nose. Added to the nose was 27.5 pounds of steel. This replaced 5.5 pounds of amatol in order to give the bomb more penetrating power. This bomb is S & M. The AN-M58 is S.

Comparison With the 500-pound GP Bomb.

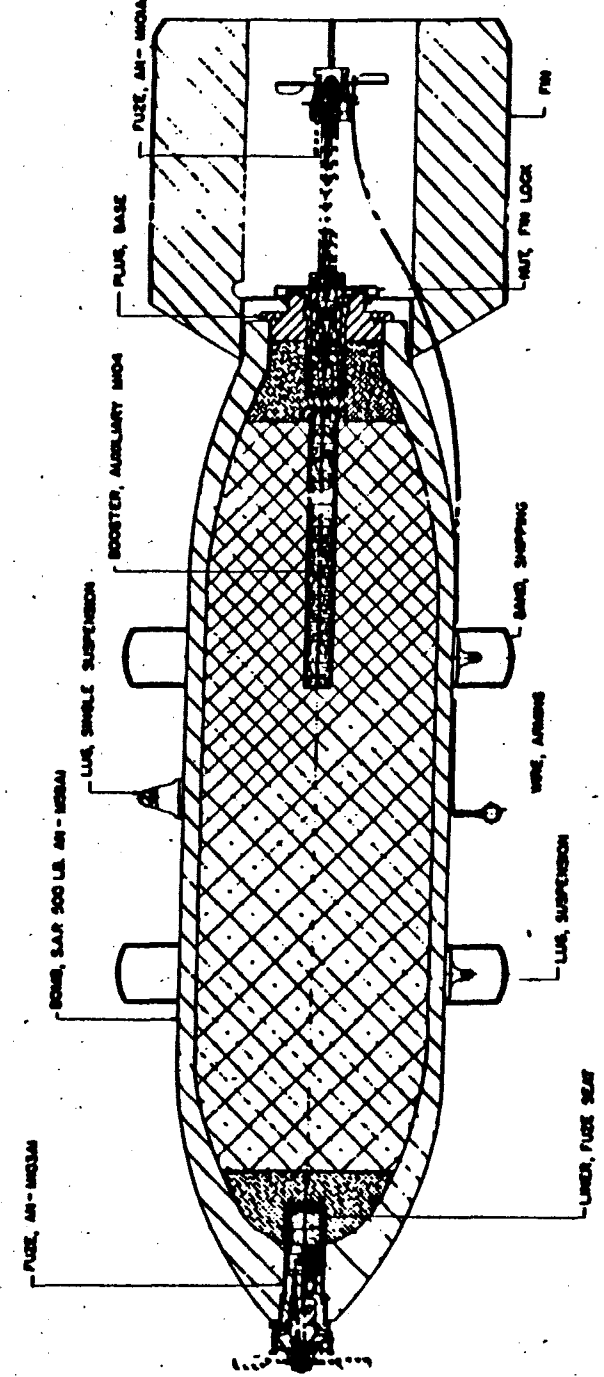
Use. The SAP bomb is used against more resistant targets than the GP bomb.

Shape. Both bombs are cylindrical; however, the diameter of the SAP bomb is much narrower (11.9 inches as compared to 14.2 inches) and the nose portion is more pointed.

Percentage of filler. Although the filler is the same, the percentage varies. The SAP carries approximately 30 to 33 percent of explosive filler, whereas the GP carries approximately 50 to 55 percent of explosive filler.

Bomb case. The SAP bomb case is made of special steel and is much heavier and thicker (0.75 in. as compared to 0.3 in.) than the corresponding GP bomb.

Fuzes. The SAP bomb, although it has the conventional fuze seat liner in the nose, is usually provided with no nose fuze but has a steel nose plug to aid in penetration. It can utilize a nose fuze in place of the steel plug. If it were to employ a nose fuze, this bomb could be effectively used as a large fragmentation bomb.



RA PD 23006

Figure 239 — 500-pound Bomb AN-M58A1—Sectionalized View

Arming wire. As it usually employs only a tail fuze type A, arming wire 0.064 inch in diameter is shipped as a component of the complete round, whereas the GP bomb utilizes a type B arming wire.

Auxiliary booster. The SAP bomb employs merely a tail auxiliary booster, whereas at the present time (although a change may be forthcoming) the GP bomb employs both a nose and tail auxiliary booster.

Other features. In all other features except size, the two bombs are alike. Both utilize a tail-base plug instead of a rear closing cap and a box type fin held firmly in place by a fin lock nut. The adapter booster in the SAP bomb is always the M102 whereas in the GP bombs either the M102 or the M115 Adapter Booster is employed, depending on the model of the bomb.

BOMB, SEMI-ARMOR-PIERCING, 1,000-POUND, AN-M59.

General. This bomb is similar except in size to the 500-pound SAP bomb previously described. It is cylindrical in shape and has a box type fin. It has approximately 307 pounds of high explosive and is adapted for both nose and tail fuze, although the nose fuze adapter (fuze seat liner) contains a steel plug instead of a fuze. The tail fuze cavity is kept free of foreign matter by an adapter plug or shipping plug. This is the largest bomb of the semiarmor-piercing type. It has the Army lugs 14 inches apart, one single suspension lug at the center of gravity, and a tail-base plug in the same manner as the GP bombs.

Use. This bomb is used against heavily reinforced buildings, docks, bridges, and seacraft.

Description. The total length of this bomb is 70.4 inches and the diameter is 15.1 inches. The case is 0.75 inch thick and weights 661 pounds. It is filled with 307 pounds of 50/50 amatol, or 318 pounds of TNT. The total loaded weight is 971 pounds with amatol, or 990 pounds with TNT filler. Percentage of filler is approximately 31 percent.

Fuzes. Fuzes provided for the 1,000-pound SAP bomb are the standard AN-M102A2 Tail Fuze with no nose fuze; however, alternates are the Nose Fuzes M103, AN-M103, M118, and M119, with Tail Fuzes AN-M102A1, M102, M114, and M106 (all modifications).

Complete Round Components. A complete round consists of the following components or their alternates:

Bomb Case AN-M59, loaded (1)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type A (1)
Fahnestock clip (1)

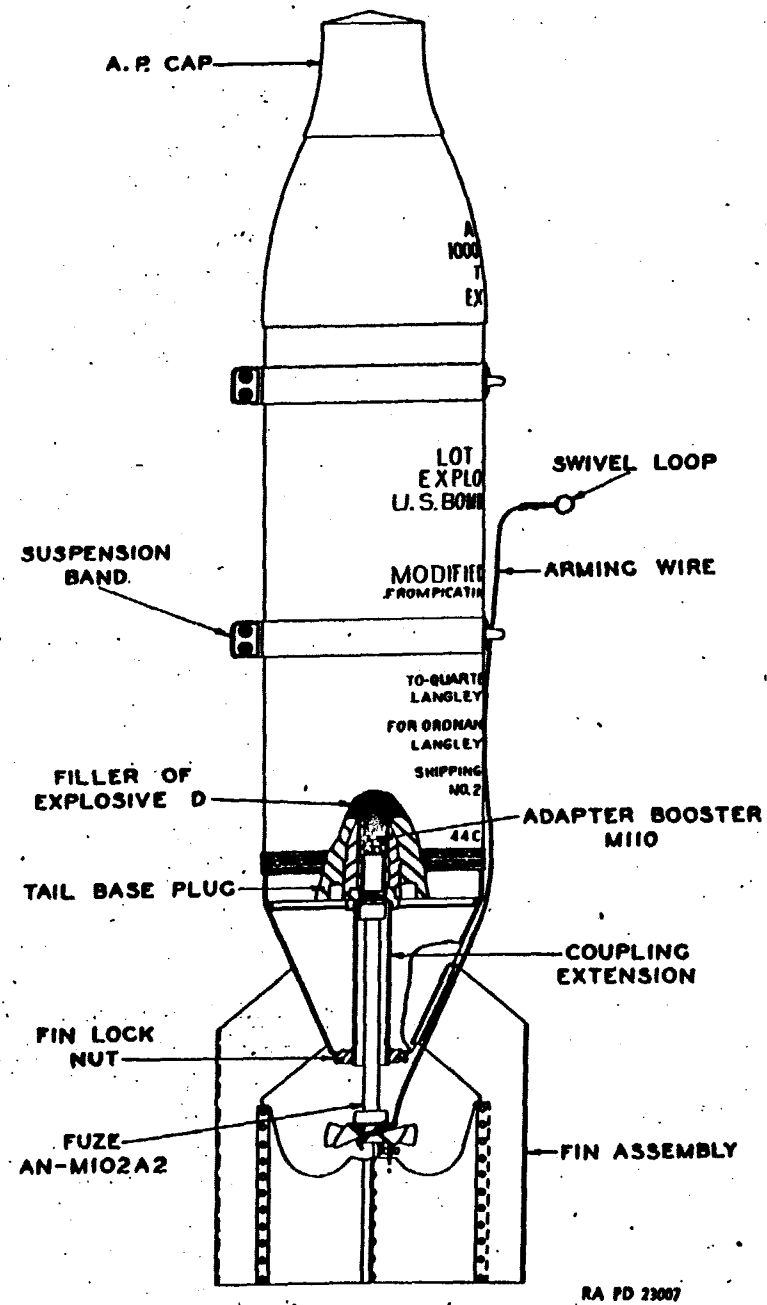


Figure 240 — BOMB, A.P., 1,000-pound, M52

BOMB, ARMOR-PIERCING, 1,000-POUND, M52.

General. The 1,000-pound armor-piercing bomb is a converted 12-inch mortar shell. The modifications included the removal of the base fuze and the incorporation of a tail-base plug which adapted the shell to receive a tail adapter booster, the M110, and a box type fin assembly by means of a coupling extension and fin lock nut. The fin lock nut holds the fin assembly around the bomb body in the same manner as described for the GP bombs, except that the threads to seat the fin lock nut are provided by the coupling extension.

Attached to the bomb body are two suspension bands which provide the lugs for double suspension. These bands fit around the circumference of the shell and are bolted in place. For dive bombing purposes, the Trunnion Band M3A1 was included in the complete round. The final addition was a type A arming wire assembly .064 inch in diameter for use in the tail fuze. This bomb can be identified by the blunt mild steel pellet on the nose.

Description. Total length of this bomb is 70.88 inches and the diameter is 12 inches. The case is 2.3 inches thick and weighs 983 pounds. It is filled with 58.35 pounds of explosive D, bringing the total weight to 1,077 pounds. Percentage of explosive filler in this bomb is 5.4 percent.

Fuzes. The bomb is fuzed with the Tail Fuze AN-M102A2. There is no nose fuze. Substitute fuzes are the AN-M102A1 and M102 Tail Fuzes.

Complete Round Components. A complete round consists of the following components or permissible substitutes:
Covered Mortar Shell M52, 1,000-pound, loaded (1)
Suspension bands (2)
Tail Fuze, AN-M102A2 (1)
Fin assembly (1)
Arming wire, type A (1)
Fahnestock clip (1)

The A1 Modification. The 1,000-pound AP Bomb M52A1 differs from the M52 only in that it has a new adapter booster which has a greater tetryl booster charge.

BOMB, ARMOR-PIERCING, 900-POUND, M60.

General. This bomb is a converted 12-inch mortar shell. Its modifications in general are the same as that previously described for the AP, 1,000-pound, M52 Bomb.

Description. Complete length of this bomb is 61.72 inches and the diameter is 12 inches. The case weighs 807.74 pounds and is filled with 43.34 pounds of explosive D to bring the total weight of the bomb to 899 pounds. Percentage of filler is approximately 5.5 percent.

Fuzes. The standard for this bomb is the AN-M102A2 Tail Fuze. Alternates are the AN-M102A1 and M102 Tail Fuzes.

Complete Round Components. A complete round consists of the following components or alternates:
Converted Mortar Shell M61, loaded (1)
Suspension bands (2)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type A (1)
Fahnestock clip (1)

BOMB, ARMOR-PIERCING, 800-POUND, M61.

General. The M61 Bomb is a converted 12-inch mortar shell. In general, the modifications involved are the same as those in the AP, 1,000-pound, M52 Bomb. It can be identified by its extremely blunt nose and threads for a windshield.

Description. Total length of this bomb is 58.72 inches and the diameter is 12 inches. Weight of the empty case is 787.28 pounds. The filler is 32.68 pounds of explosive D, bringing the weight of the complete round to 853 pounds. Percentage of filler is approximately 3.8 percent.

Fuzes. The standard fuze for this bomb is the Tail Fuze AN-M102A2 with the AN-M102A1 and M102 as alternates.

Complete Round Components. A complete round consists of the following components or permissible alternates:
Converted Mortar Shell M61, loaded (1)
Suspension bands (2)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type A (1)
Fahnestock clip (1)

BOMB, ARMOR-PIERCING, 600-POUND, M62.

General. This bomb is a converted 10-inch shell. Its modifications in general are the same as those previously described for the AP, 1,000-pound, M52 Bomb. It can be identified by the sharply tapering nose windshield.

Description. The total length of this bomb is 62.06 inches and its diameter is 10 inches. Weight of the empty case is 575 pounds. Filled with 33.61 pounds of explosive D, the complete round weighs 634 pounds. The percentage of filler is approximately 5.2 percent.

Fuzes. This bomb is fuzed with the AN-M102A2 Tail Fuze, and the AN-M102A1 and M102 are provided as alternates.

Complete Round Components. A complete round consists of the following components:
Converted AP Shell M62, loaded (1)
Suspension bands (2)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type A (1)
Fahnestock clip (1)

A1 and A2 Modifications. The 600-pound AP Bomb M62 used the M110 Adapter Booster. The M62A1 utilizes the M113 Adapter Booster, whereas the M62A2 incorporates the M114 Adapter Booster. In general, the bombs are the same in all other respects.

BOMB, ARMOR-PIERCING, 1,400-POUND, M63.

General. This bomb is a converted AP shell which weighs approximately 1,400 pounds. Its modifications in general correspond to those described for the AP, 1,000-pound, M52 Bomb.

Description. The total length of this bomb is 69.1 inches and the diameter is 14.0 inches. It is filled with 35 pounds of explosive D and weighs, 1,412 pounds. Percentage of explosive filler is approximately 2.5 percent.

Fuzes. The standard for this round is the Tail Fuze AN-M102A2. Alternates are the AN-M102A1 and the M102 Tail Fuzes.

Complete Round Components. The complete round consists of the following components:
Converted AP Shell M63, loaded (1)
Suspension bands (2)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type A (1)
Fahnestock clip (1)

BOMB, ARMOR-PIERCING, 1,600-POUND, AN-MK. 1.

General. This bomb was designed by the Navy and is interchangeable between the Army and Navy. It is standard for issue and manufacture. It is cylindrical in shape and has a pointed nose, tapered tail, and box type fin assembly.

Uses. It is designed to penetrate the heaviest horizontal armor of combatant ships and detonate below deck. It should not be employed against unarmored or lightly armored craft, as the fuze delay may permit the bomb to pass completely through the ship before detonating. Due to the thickness of the walls of this bomb, the explosive cavity is small compared to that of GP bombs and it has

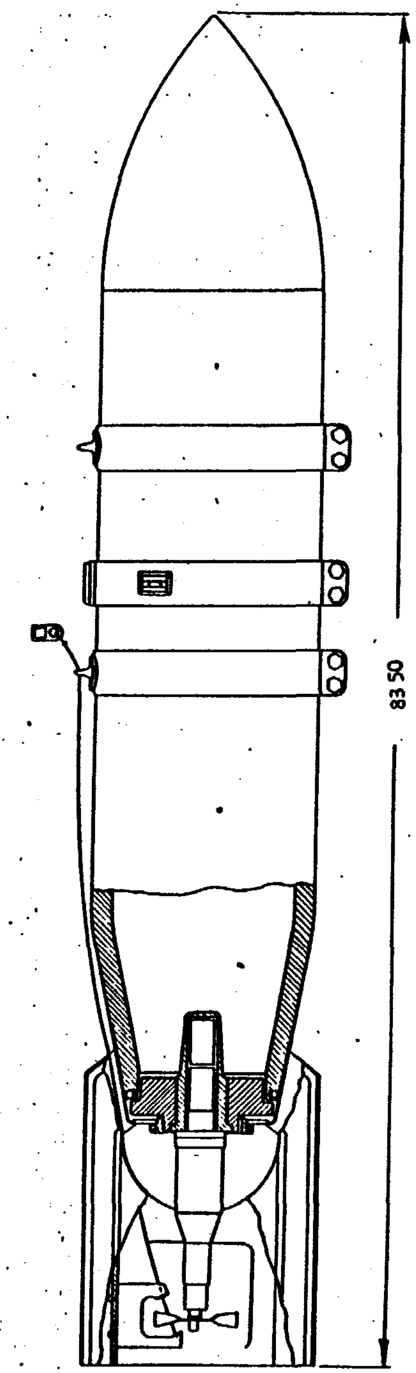


Figure 241 — BOMB, A.P., 1,600-pound, Mk. 1, Complete Round

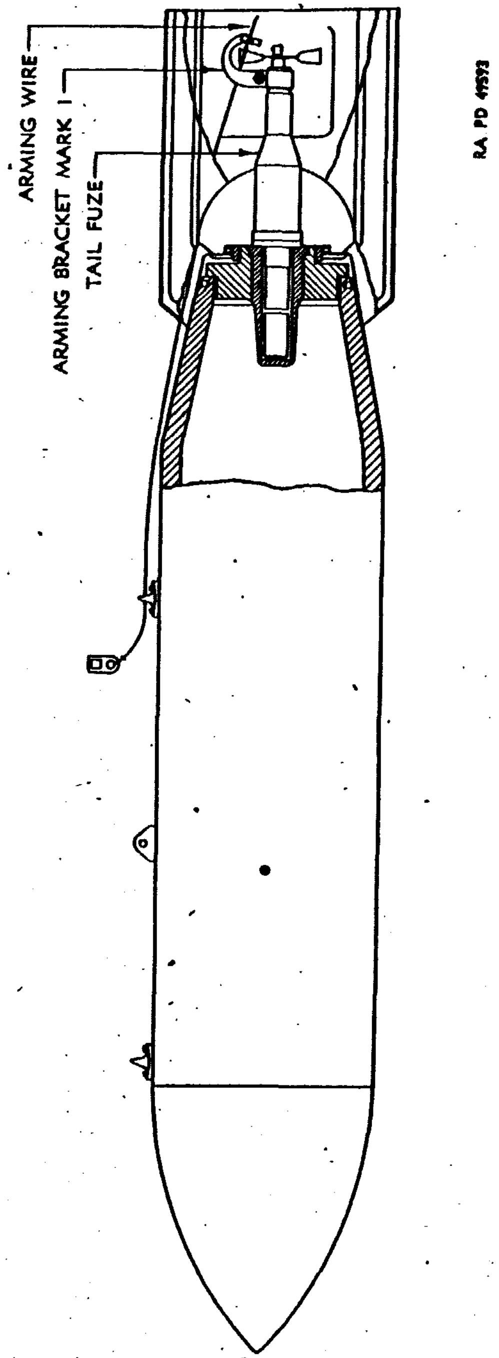


Figure 242 — BOMB, A.P., 1,600-pound, AN-Mk. 1, Complete Round

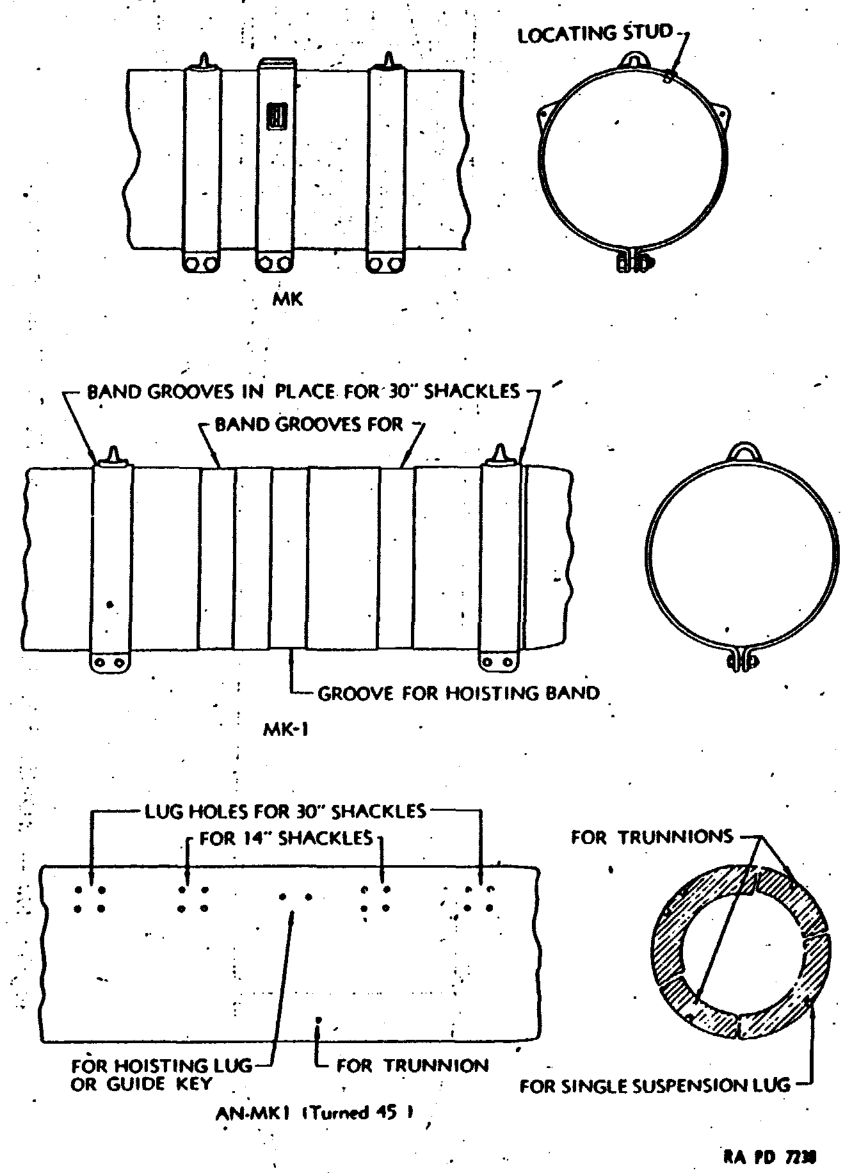


Figure 243 — Modifications of 1,600-pound A.P. Bomb

not as great an underwater effect for a near miss. It is adapted for tail fuze only.

Models. There are three modifications of this bomb which differ principally in the method of attachment of suspension accessories.

The Mark I has two suspension bands and one hoisting band, each of which is located by a stud on the inner surface of the band engaging a recess in the bomb body.

The Mark I or AN-Mk. I (early lot) has two suspension bands and one hoisting band, each of which is located by a shallow groove machined in the bomb case. (Five grooves are provided, the outer pair for locating the bands for 30-inch racks and the next pair to locate the bands for the 14-inch racks, the center groove for locating the hoisting band.)

The AN-Mk. I of current design has blind holes drilled and tapped in the bomb case. Suspension lugs, hoisting lugs and bolts, therefore, as well as trunnions, are packed in the fin crate for attachment as required. A guide key is also furnished for use when using torpedo sling suspension. The vane stop fork is not fitted to the tail of the AN-Mk. I Bomb; instead, an Arming Bracket Mk. I is attached to the fuze.

Suspension for dive bombing is provided by a combination hoisting and trunnion band for the Mk. I and Mk. I-Mod. 1. For the AN-Mk. I, the trunnions screw into the holes in the bomb case.

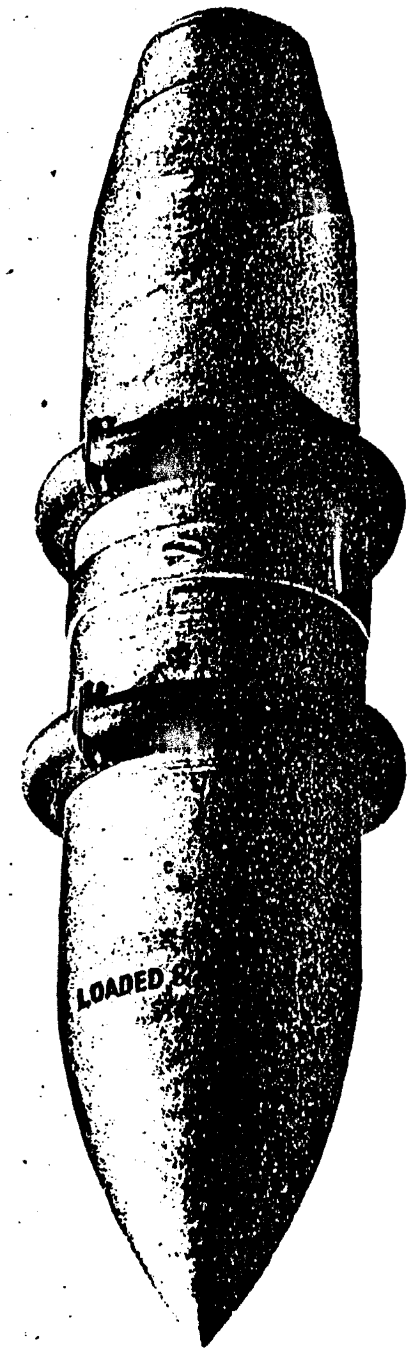
Description. The length of this bomb is 83.5 inches and the diameter is 14 inches. The total weight of this bomb when loaded with 228 pounds of explosive D is 1,613 pounds. Percentage of filler is 14.1 percent.

Fuzes. Fuzes provided for this bomb are the standard AN-Mk.228 Tail Fuze or its substitute, the AN-Mk.28 Mod. 1.

Complete Round Components. A complete round consists of the following components:

Bomb body, including:
- Filler
- Auxiliary booster
- Adapter
- Fin lock nut
- Suspension bands (or suspension lugs and bolts)
- Hoisting band (or hoisting lugs and bolts)

Arming Bracket, Mk. I (packed with fin assembly)
BOMB, Fuze, AN-Mk.228, Mod. 1 (tail)
Fin assembly
Trunnion band (or threaded trunnions, for dive bombing)
Arming, wire, assembly



RA PD 7237

Figure 244 — BOMB, A.P., 1,600-pound, Mk. 1, as Shipped

BOMB, ARMOR-PIERCING, 1,000-POUND, AN-Mk. 33.

General. This bomb is at the present time the latest armor-piercing bomb designed by the Navy for joint Army and Navy use. It is standard for issue and manufacture. It is cylindrical in shape and has a pointed nose, tapered tail, and box type fin assembly.

Uses. Similar to the 1,600-pound armor-piercing bomb, it is designed to penetrate heavy horizontal armor plate of combatant ships and to detonate below deck. It should not be employed against unarmored or lightly armored craft as the fuze delay may permit the bomb to pass completely through the ship before detonating. Due to the thickness of the walls of this bomb, the explosive cavity is small compared to that of the GP bombs and it has not as great an underwater effect in case of a near miss. It is adapted for a tail fuze only.

Bomb Body Description. The bomb body is of the same design as the 1,600-pound AN-Mk. I AP Bomb.

It is cylindrical in shape with a slightly tapered tail and a round nose ending in a sharp point. The nose portion of the bomb is solid, bringing the total weight of the empty bomb to between 800 and 825 pounds. The rear portion is threaded to receive a tail-base plug in the same manner and for the same purpose as that found in the GP bombs. Drilled and tapped in the bomb body are blind holes protected by shipping plugs threaded into these holes. Approximately 29 inches from the nose will be found four blind holes for the first of the double suspension lugs. When assembled, the shipping plugs are removed by means of a screwdriver and the suspension lug is then securely attached by means of four screws which are safety-wired in place. Fourteen inches from the first set of holes will be found a second set of four blind holes for the second suspension lug. Between these two sets of holes are two more blind holes for attachment of a hoisting lug. The body will also have two blind holes on opposite sides into which trunnions are threaded. Opposite the hoisting lug will be found the final series of holes to receive the single suspension lug or guide key. Guide keys are provided for longitudinal bracing of the bomb when suspended by slings in the torpedo position, for example in Navy TBD and TBF planes.

A box type fin assembly is provided which seats around a machined-down portion at the tail end of the body. It is held in place by a fin lock nut which screws around the tail-base plug. The fuze used is the AN-Mk.228. It utilizes an arming bracket over the fuze which alines with suspension lugs in the same manner as described for the 1,600-pound AP AN-Mk. I.

Description. Total length of this bomb is 73.0 inches and the diameter is 12.0 inches. Weight of the bomb complete with a filler of

COMPLETE ROUND CHART—SAP AND AP BOMBS

Type, Weight, Designation, and Status	Filler	Tail Auxiliary Booster	Tail Adapter Booster	Fuze (Tail)	Fuze (Nose)
Bomb, SAP, 500 lb, AN-M58 (S)	155 lb Amatol	M104	M102	AN-M101A2(1)	Steel Plug(2) Fuze Seat Liner
Bomb, SAP, 500 lb, AN-M58A1 (S&M)	150.4 lb Amatol	M104	M102	AN-M101A2(1)	Steel Plug(2) Fuze Seat Liner
Bomb, SAP, 1,000 lb, AN-M59 (S&M)	308 lb Amatol	M104	M102	AN-M102A2(3)	Steel Plug(2) Fuze Seat Liner
Bomb, AP, 1,000 lb, M52 (S)	58.35 lb Exp. D.	None	M110	AN-M102A2(4)	None
Bomb, AP, 900 lb, M60 (S)	43.34 lb Exp. D.	None	M110	AN-M102A2(4)	None
Bomb, AP, 800 lb, M61 (S)	32.68 lb Exp. D.	None	M110	AN-M102A2(4)	None
Bomb, AP, 600 lb, M6A2 (S)(5)	33.61 lb Exp. D.	None	M114	AN-M102A2(4)	None
Bomb, AP, 1,400 lb, M63 (S)	35 lb Exp. D.	None	M110	AN-M102A2(4)	None
Bomb, AP, 1,600 lb, AN-Mk. 1 (S&M)	228 lb Exp. D.	Navy 180 g	....	AN-Mk. 228	None
Bomb, AP, 1,000 lb, AN-Mk. 33 (S&M)	146 lb Exp. D.	Navy 180 g	....	AN-Mk. 228	None

(1) Fuze AN-M101A1, M101, M113 may be substituted.
(2) Fuze AN-M103, M103, M118 or M119 may be used.
(3) Fuze AN-M102A1, M102, M114 may be substituted.
(4) Fuze AN-M102A1 or M102 may be used.
(5) M62 uses Adapter Booster M110; M62A1 uses Adapter Booster M113.

FUZES USED IN AP AND SAP BOMBS

Fuze Designation	Position in Bomb	Booster in Fuze?	Bomb for Which It Is Adapted	Method of Arming	Primer Detonator	Action on Impact
AN-M101A1	Tail	No	500 lb SAP	Arming Vane w/mech. del.	M14 or M14A1	Nondelay to 0.1 sec
AN-M102A2	Tail	No	600 to 1,400 lb AP	Arming Vane w/mech. del.	M14 or M14A1	Nondelay to 0.1 sec
AN-M103	Nose	Yes	All SAP	Arming Vane w/mech. del.	None	Selective, Inst. or 0.1 sec
M113	Tail	No	500 lb SAP	Arming Vane	M16	4 to 5 sec or 8 to 11 sec del.
M114	Tail	No	1,000 lb SAP	Arming Vane	M16	4 to 5 sec or 8 to 11 sec del.
M116	Tail	No	500 lb SAP	Arming Vane w/mech. del.	M16	4 to 5 sec or 8 to 11 sec del.
M117	Tail	No	1,000 lb SAP	Arming Vane w/mech. del.	M16	4 to 5 sec or 8 to 11 sec del.
M118	Nose	Yes	All SAP	Arming Vane	None	4 to 5 sec del.
M119	Nose	Yes	All SAP	Arming Vane	None	8 to 11 sec del.
M124	Tail	No	500 lb SAP	....	....	1 to 12 hr del.
M125	Tail	No	1,000 lb SAP	....	....	1 to 12 hr del.
AN-Mk. 228	Tail	....	1,000 and 1,600 lb AP	Arming Vane w/mech. del.	None	0.08 sec del.

146 pounds of explosive D is 1,004 pounds. Percentage of filler is approximately 14.5 percent.

Fuzes. The standard fuze for this bomb is the AN-Mk. 228 Tail Fuze. Alternate or substitute fuzes are the AN-Mk.28, Mod. 1 or the Mk. 28 Tail Fuze.

Complete Round Components. A complete round consists of the following components:

Bomb Case AN-Mk.33, 1,000-pound, loaded (1)
Tail Fuze, AN-Mk.228 (1)
Fin assembly (with lugs, keys, trunnions, and screws) (1)
Arming wire, type A (1)
Fahnestock clip (1)

FURTHER REFERENCES: A complete list of references dealing with bombs may be found at the close of the final chapter of this section.

Chapter 4

Depth Bombs

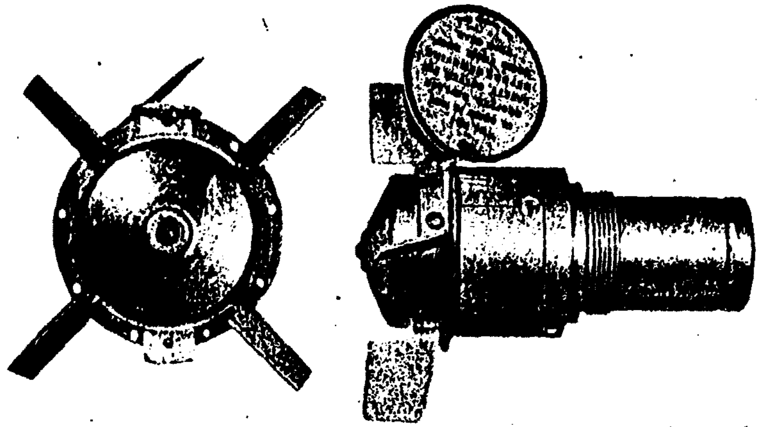
GENERAL.

Depth bombs were used by the Navy for a considerable length of time before their adoption by the Army. This is very natural, of course, since depth bombs are designed for use entirely against watercraft. After the introduction of the policy to make bombs interchangeable between the Army and Navy, the Army became concerned about depth bombs. Those designated as AN are very similar in operation and construction to one another.

Depth Bomb, FUZE, Transverse, Hydrostatic, AN-Mk. 224.

General. This fuze is designed to function in response to hydrostatic pressure at a predetermined depth. As issued, the fuze is set for a depth of 50 feet, but this setting may be changed for 25, 75, 100, or 125 feet. The fuze is installed in a transverse fuze cavity just forward of the bomb center.

Description. The fuze is issued in three subassemblies: pistol, booster, and booster extender. When assembled to the bomb, the fuze protrudes slightly on both sides and requires a section of arming wire for each end. Both sections of arming wire must be withdrawn in order to permit the fuze to operate.



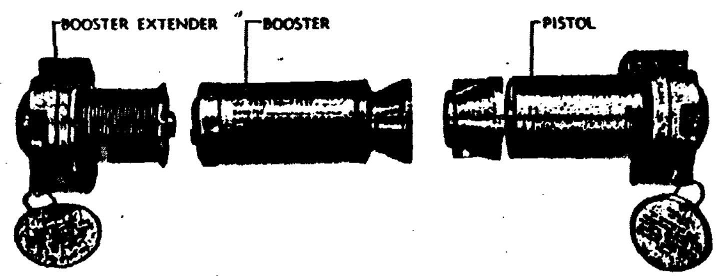
RA PD 2135

Figure 245 — FUZE, Bomb, AN-Mk. 219

The fuze is approximately 3.6 inches in diameter and 16.6 inches in length when completely assembled. When inserted into the bomb body, the pistol assembly is bolted to one side of the bomb and the extender is bolted to the opposite side.

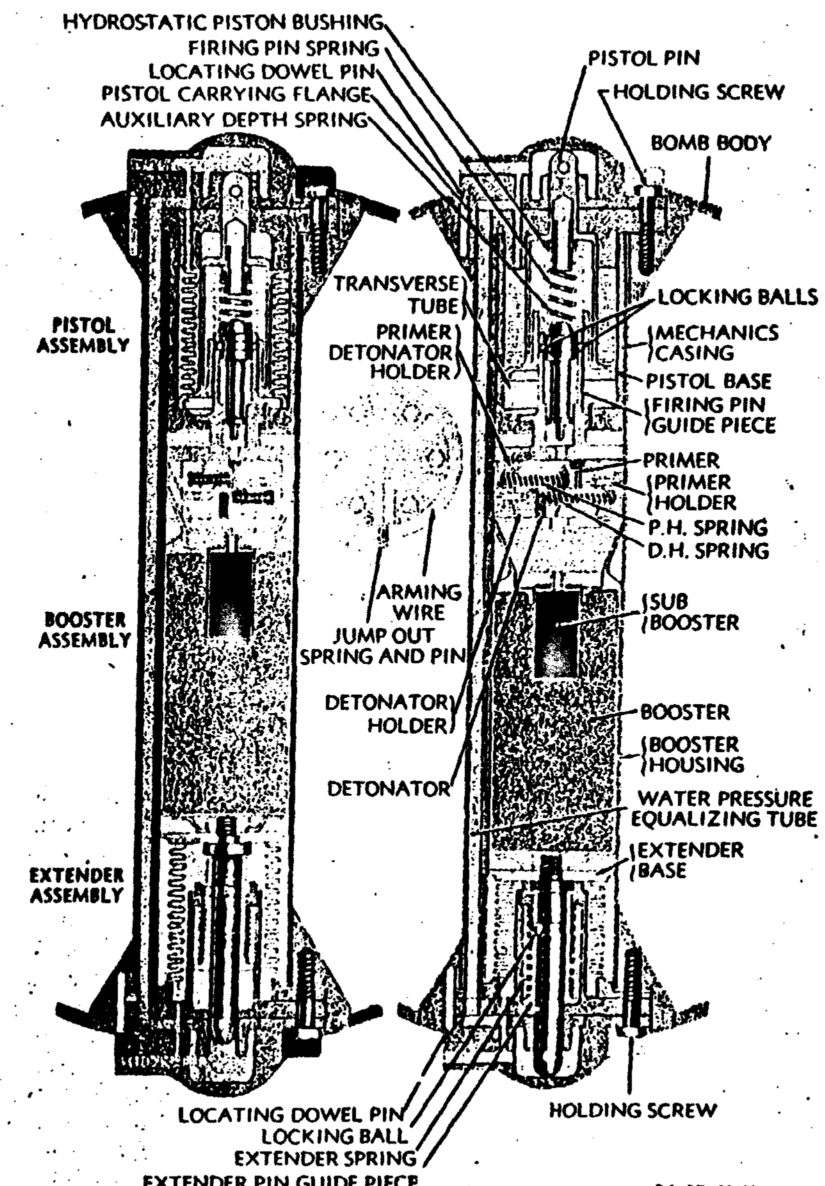
The explosive train for this fuze is interrupted by the primer assembly being held out of alinement with the detonator assembly and both of these assemblies being out of line with the firing pin and subbooster. The primer assembly is located in a sliding wedge which is under a spring load, with a similar sliding wedge containing the detonator assembly under a spring load in the opposite direction.

The booster extender assembly contains a bellow-shaped hydrostatic piston, an extender base, and extender pin. The extender pin, having a small groove milled in it, is held, by means of three locking



RA PD 2136

Figure 246 — FUZE, Bomb, Hydrostatic, AN-Mk. 224



RA PD 23008

Figure 247 — FUZE, Bomb, Hydrostatic, AN-Mk. 224—Transverse

balls which are 120 degrees apart, to an extender pin guide piece which has three corresponding holes to receive the locking balls and keeps the locking balls in position by means of a sleeve. Movement of the guide piece is counteracted by an extender spring which fits around the guide piece. An arming pin or jump-out pin prevents movement of the extender pin and, therefore, prevents movement of the booster extender assembly when the fuze is in the unarmed position.

The pistol assembly contains a hydrostatic piston which is also bellow shaped, a pistol base, and firing pin. The firing pin at its upper end has a small groove milled in it and is held, by means of two locking balls 180 degrees removed, to a firing pin guide piece which has two corresponding holes to receive the locking balls. The firing pin guide piece is covered by a sleeve which is part of the pistol base. Between the pistol base and the firing pin will be found a main spring and, if the depth setting so requires, an auxiliary spring, tending to counteract water pressure.

The pistol base at the top portion ends in a protrusion known as the pistol pin. Inserted into the pistol pin is an arming pin or jump-out pin which prevents the entire pistol assembly from operating when the fuze is in the unarmed position. The entire pistol assembly is encased in a mechanism casing which can be removed to change or add depth springs so as to vary the depth setting.

Function. The bomb is dropped and the arming wire is retained in the plane. The arming pins are ejected by their springs freeing the pistol pin and extender pin, and arming the fuze.

As the bomb sinks, water enters the inlets in the fuze and flows into the hydrostatic pistons and water pressure equalizing tube thus putting uniform pressure at opposite ends of the fuze. This pressure tends to force the pistol base and extender base toward the center of the fuze.

Considering the booster extender assembly, water pressure acts on a hydrostatic piston and extender base forcing the two, which are directly attached and therefore act as a unit, to move toward the center of the fuze (the piston merely expanding and acting as the water carrier). The extender pin, being directly attached to the extender base, carries with it the extender pin guide piece by means of three locking balls. The guide piece compresses the extender spring. The extender spring therefore counteracts the pressure created by the water and in so doing slows down the movement of the extender base. As this movement continues, the locking balls reach a recess in the sleeve, which is found between the guide piece and spring. The locking balls fall into this recess and free the extender pin from the guide piece and, therefore, from the extender spring. The water

pressure no longer being counteracted by the extender spring quickly drives the extender base and pin toward the center of the fuze. This occurs before a depth of 25 feet is reached.

The movement of the extender base serves to move the booster assembly to which the base is attached by threads toward the center of the fuze. The booster assembly at its lower end has a funnel-shaped opening which, as it moves toward the center of the fuze, forces the primer detonator holders to act against their springs bringing the primer and detonator into the armed position or in line with the firing pin. The booster assembly also carries the subbooster and booster charge into close position with the detonator so as to effectively receive the detonating wave.

Considering the pistol assembly, water pressure acting through a hydrostatic piston causes the pistol base with its sleeve to move toward the center of the fuze. In so doing, the pressure of the water is counteracted by a main firing pin depth spring and an auxiliary depth spring, if present. The greater the tension of the depth spring or springs, the more is the water pressure required to move the pistol base, with the sleeve, inward. As the sleeve moves inward, the two locking balls which hold the firing pin to the guide piece are almost uncovered. It is prevented from moving any farther by the mechanism casing. The firing pin guide piece due to the pressure produced by the water at the extender is forced toward the pistol end of the fuze. The locking balls are uncovered and fall into the recess of the pistol base and release the firing pin.

The firing pin is now driven by its compressed main spring into a primer which ignites. The flame from the primer ignites the detonator which starts a wave to function the subbooster. The subbooster of tetryl functions the booster.

Depth settings. There are five possible depth settings which may be obtained with this fuze, namely: 25, 50, 75, 100, and 125 feet. Unless otherwise marked, the fuze as issued will function at 50 feet. This may be changed by the insertions of the appropriate springs which are supplied in the can in which the fuze is packed. There are four springs supplied in all. Two of these are main springs, one being a 25-foot depth spring and the other a 50-foot depth spring. One or the other must be used, never both, in all depth settings because the width of these springs (½ inch) allows either one to fit over and around the firing pin. The two auxiliary springs give additional depth settings of 25 and 75 feet and must be used for depth settings over 50 feet. The diameter of these springs is ¾ inch so as to allow them to fit around the main springs. These auxiliary springs are too wide in diameter to fit over and around the firing pin, and must be used in conjunction with a main spring. The springs are painted different colors to differentiate between them. The depth settings and how each is obtained may be summarized in the following table:

Depth Setting	Main Spring	Auxiliary Spring	Color of Spring	Diameter of Spring
25 ft	25 ft	None	Yellow	½ in.
50 ft	50 ft	None	Black	½ in.
75 ft	50 ft	25 ft	Black (main) Green (aux.)	½ in. ¾ in.
100 ft	25 ft	75 ft	Yellow (main) Red (aux.)	½ in. ¾ in.
125 ft	50 ft	75 ft	Black (main) Red (aux.)	½ in. ¾ in.

Change of depth setting. To change depth settings of this fuze proceed as follows:

Unscrew primer detonator holder after forcing counterclockwise by hand to break staking.

Remove set screw in mechanism casing and unscrew casing from pistol carrying flange.

Remove guide piece, firing pin, and locking balls as a unit from hydrostatic piston bushing exposing the spring cavity.

For function at 25-foot depth, remove the black spring and substitute the yellow spring.

To function at 75-foot depth, leave the black spring in place and insert the larger green spring over it.

For function at 100-foot depth, remove the black spring and insert the small yellow spring, and over it, the larger red spring.

For 125-foot depth, use the black spring and the red spring.

Assemble firing pin and locking balls in guide piece and insert as a unit into the hydrostatic piston bushing, resting the firing pin on the 0.5-inch spring.

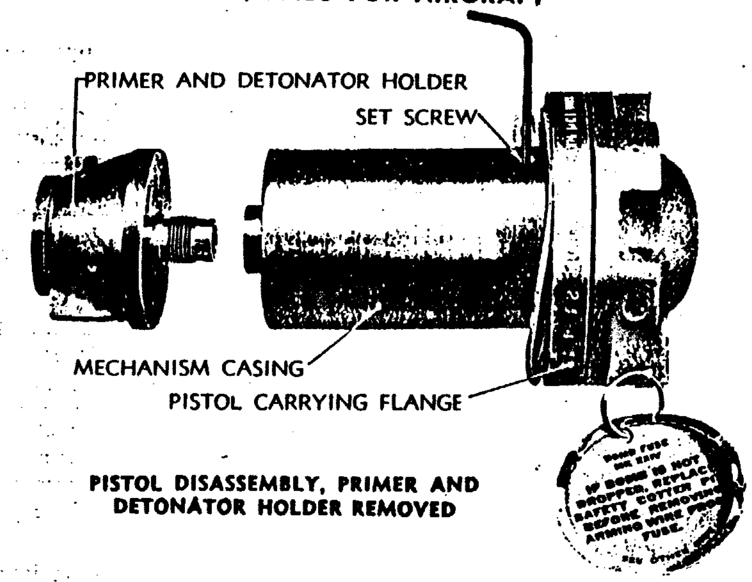
Assemble the mechanism casing to the pistol carrying flange, taking care that the guide pin enters the hole in the guide piece. Screw mechanism casing home and replace the set screw.

Reassemble primer and detonator holder to guide piece, taking care that end of firing pin is centered. Screw tightly home and stake by means of a suitable tool.

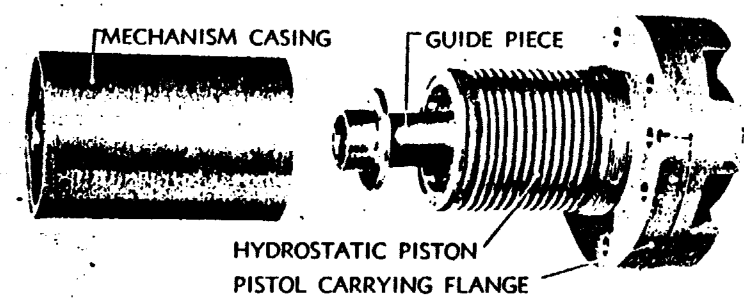
Mark pistol head to indicate depth setting. If the fuze is repacked, mark the packing can and data card as well.

Modifications. The late modification 1 fuze and the newer modification 2 fuze have certain differences as described below:

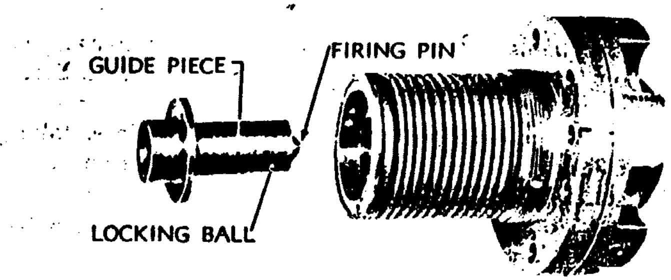
In an effort to make the fuzes watertight and to adapt them to



PISTOL DISASSEMBLY, PRIMER AND DETONATOR HOLDER REMOVED



MECHANISM CASING REMOVED



GUIDE PIECE AND FIRING PIN ASSEMBLY REMOVED RA PD 2137

Figure 248 — Disassembly of Pistol for Insertion of Auxiliary Depth Spring, FUZE, AN-Mk. 224

a new type packing container, the design of the jump-out pin was altered so as to fit into the fuze body proper without the pin protruding from the circumference of the fuze.

All of the water ports leading into the fuze were eliminated except the jump-out pinhole which acts as the water port after the emission of the jump-out pin. This jump-out pin is designed with a rubberized extender washer-like affair near the outer end, which fits up against the surface of a shoulder in the jump-out pinhole making the fuze watertight.

Instead of two holes through the jump-out pin, there is now but one. This makes it only possible to insert either a cotter pin or an arming wire at one time. It is therefore necessary to apply pressure to the end of the jump-out pin in order to prevent it from flying out during the interval between the time the cotter pin is removed and the arming wire is inserted.

As an aid to accomplishing the withdrawal of the cotter pin and the insertion of the arming wire, a special tool is used which has been designed to hold the jump-out pin in place.

Packing. This fuze is packed as three subassemblies: pistol, booster, and booster extender are in a sealed metal container which contains auxiliary springs and 12 screws for attaching the fuze to the bomb. Four such containers are packed per metal crate or box.

Depth Bomb, FUZE, Transverse, Hydrostatic, AN-Mk. 234. The AN-Mk. 234 recently designed will replace the AN-Mk.224. This new fuze is designed to allow for depth settings which can be varied from the outside of the fuze without the necessity for disassembling the fuze and changing springs. This fuze will also utilize the special tool which is a modification of a screwdriver to hold the jump-out pin in place when the cotter pin is removed and the arming wire is inserted.

Depth Bomb, FUZE, Nose, AN-Mk. 219.

General. This fuze is an arming vane type with mechanical delay. It arms in 600 to 850 feet of air travel or about 6 seconds, and functions on impact with water or any denser medium with instantaneous action.

The fuze is shipped with an adapter so that when fuze and adapter are assembled, they will fit in the fuze cavity in the nose of the depth bomb.

Two booster pellets each containing 180 grams of TNT are shipped in place in the bomb in the booster cavity.

The fuze is packed one per metal container which is sealed by a soldered metal tear strip.

Use. This fuze is standard for Navy demolition bombs and in a special purpose fuze for the depth bomb when surface demolition or blast effect is desired with this bomb.

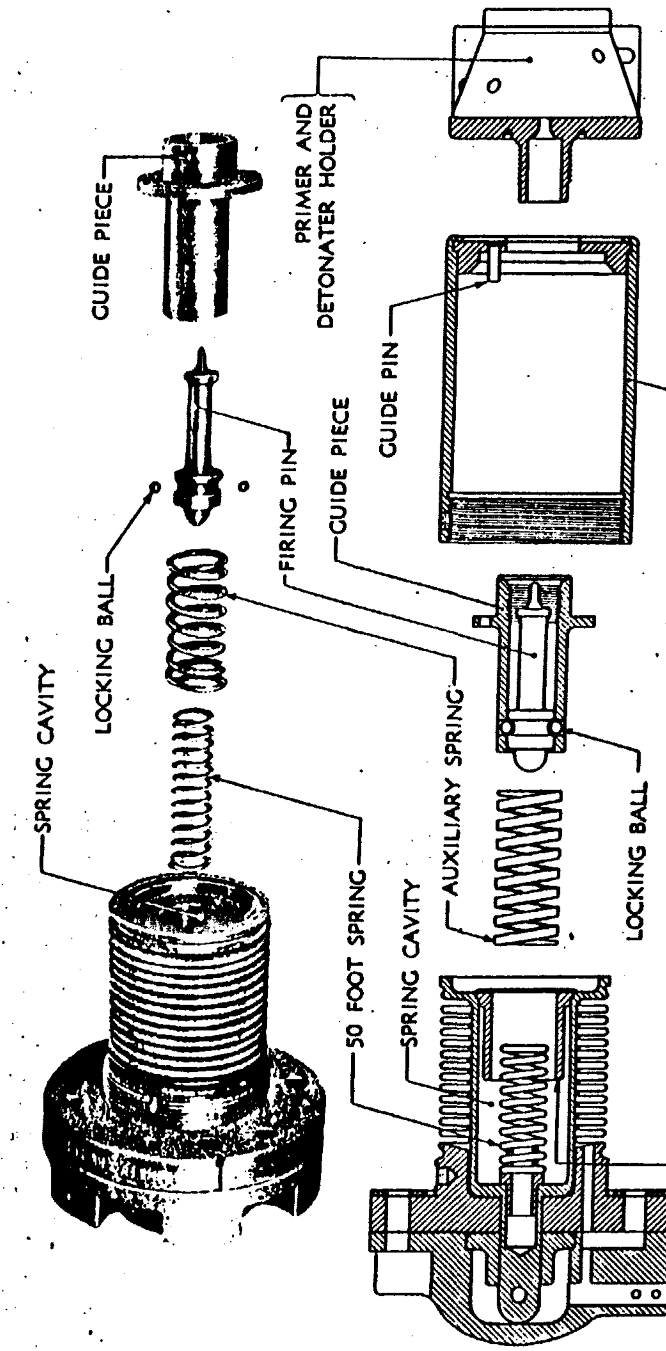


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Figure 249 — FUZE, AN-Mk. 224, Reassembly of Pistol, With Auxiliary Depth Spring

Depth Bomb, FUZE, Nose, AN-Mk. 221.

General. This fuze is an arming vane type with mechanical delay. It arms in 800 to 1,100 feet of air travel and functions on impact with water or any denser medium with a delay of 0.01 second.

This fuze differs from the AN-Mk. 219 in the following main features:

A delay of 0.01 second is incorporated in the explosive train of the fuze.

The fuze body itself is threaded to be screwed into the fuze cavity of the depth bomb, consequently no adapter is used.

When this fuze is used, only one 180 gram TNT booster pellet is used in the fuze cavity, another must be removed before assembling of the fuze to the bomb.

Use. This fuze is standard for Navy domolition bombs and is a special purpose fuze for the depth bomb where blast effect is desired. For all normal usage, a hydrostatic fuze will function the depth bomb. Due to the fact that depth bombs are light case construction, the use of this fuze with its incorporated delay of 0.01 second is not recommended as the case may break before the fuze will function.

Models AN-Mk. 221 not antisubmarine. This includes AN-Mk. 221 and AN-Mk. 221M1 except lots 21, 22, 23 and AN-Mk. 221M3 and M4. These models are all the same being only slightly changed from the AN-Mk. 221 Fuze and are manufactured by different concerns. The AN-Mk. 221 will arm in approximately 850 feet air travel. All these fuzes will function, if dropped from 2,000 feet or higher, on impact with water.

Models AN-Mk. 221 antisubmarine. This includes AN-Mk. 221M1 lots 21, 22 and 23 and AN-Mk. 221M2. These fuzes were modified to be inoperative on water impact when released from less than 7,000 feet altitude. The AN-Mk. 22M1 are marked "A.S." fuzes if they are of the antisubmarine lots. All of the AN-Mk. 221M2 are built the same way, and therefore there is no need to mark these "A.S."

Depth Bomb, FUZE, Tail, Hydrostatic, AN-Mk. 229M1.

General. This is an arming vane type of fuze with mechanical delay. Upon arming, detents (spring actuated pins) fly out so as to allow the bellows to operate. It is a tail fuze and when armed it functions on water pressure. Depth setting is made by a dial located on the exterior of the fuze body which operates a long spindle in the interior of the bomb fuze. This varies the compression on the depth spring. By turning the dial, one of five settings can be obtained, namely: 25-, 50-, 75-, 125-, and 175-foot depths.

In operation, it is somewhat similar to the AN-Mk. 224 except that water pressure forces the initiating explosive into a stationary firing pin with only one system of bellows. The AN-Mk. 230 used on the

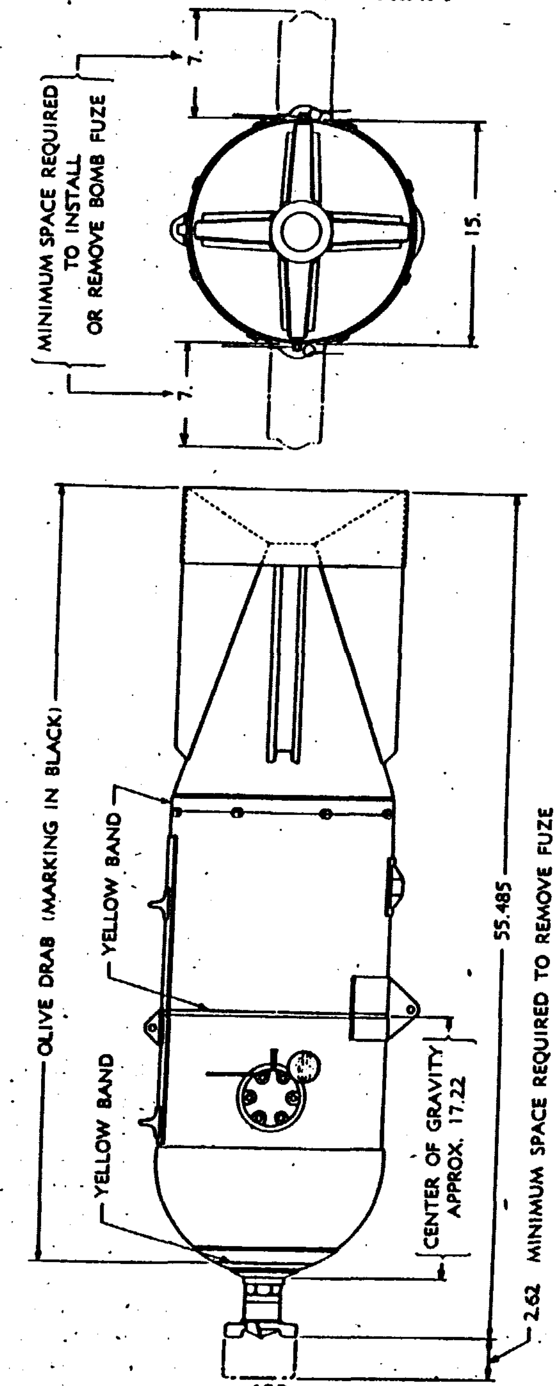


Figure 250 — BOMB, Depth, 325-pound, AN-Mk. 17

new GP bombs resembles this fuze; however, it is smaller in diameter and has different threads to fit the GP bombs.

Actually there are no AN-Mk. 229 (no mod.) Fuzes in service. Only the AN-Mk. 229 Mod. 1 Fuzes have been issued for service use.

BOMB, DEPTH, 325-POUND, AN-MK. 17M1.

General. This bomb is a light case bomb which is intended for use primarily against submarines but with special fuzing may be used for demolition effect on surface craft. It weighs 325 pounds of which 243 pounds or 75 percent is high-explosive filler.

Description of the Bomb Body. The body of the bomb is constructed from 1/16-inch sheet metal with a well rounded nose and a flat recessed base. The nose end of the bomb is adapted to receive the adapter for the AN-Mk. 219 Fuze or the AN-Mk. 221 Fuze directly. These fuzes are used only when blast effect is desired.

Approximately 1 foot behind the nose of the bomb, a cavity passes through the bomb body from one side to the opposite side. This cavity is known as the transverse tube and serves as the housing for the AN-Mk. 224 Hydrostatic Fuze. The bomb is shipped unfuzed with suitable plugs and plates protecting the fuze cavities. These cavities are swabbed with gun slushing or rust-preventive compound and must be cleaned of this and other foreign matter before a fuze is assembled.

Welded to the top of the bomb body with the first lug approximately ½ inch behind the end of the ogive of the bomb and the second lug 14 inches further to the rear, are dual suspension lugs which permit the suspension of this depth bomb in the standard Army B-7 shackle.

A hoisting lug is approximately 6 inches behind the first lug and in line with both lugs. This hoisting lug is simply an L-shaped piece of metal with its base welded to the bomb body and along the long axis of the bomb. This lug protrudes from the body approximately 1 inch and it is designed to accommodate the hoisting hook of the Navy portable bomb hoist.

If the bomb is to be used in an Army bomber requiring the use of the B-7 shackle, then this L-shaped Navy hoisting lug must be gently pried to one side or it will interfere with the operation of the B-7 shackle. The lug may be bent to one side and out of alinement with the B-7 shackle by the insertion of a piece of drill rod into the hoisting hole and applying a bending force to the lug. Under no condition may a hammer or similar instrument be used to pound the lug to one side.

If this bomb is to be suspended from the belly of certain planes, the single suspension lug will be used. This lug is located 180 degrees away from the hoisting lug and at the approximate center of gravity

of the bomb. This lug is 4 inches wide and protrudes from the bomb body approximately 1.6 inches.

Approximately eight inches to the rear of the suspension lug is located a small metal protrusion which serves as a seat for the steadying forks of the Mk. XLI Bomb Rack. This metal protrusion is 3 inches wide and protrudes from the bomb body 0.7 of an inch.

Description of Tail Fin Assembly. Assembled to the rear of the bomb body by eight bolts is the tail fin assembly. The tail fin assembly consists of a frustum (bottom half) of a cone, 15 inches in diameter at the base, 4.35 inches in diameter at the top, and approximately 22 inches long. The base of the frustum has been drilled and tapped to receive eight bolts which pass through the body of the bomb and anchor the tail fin assembly to the bomb body.

Welded to the frustum are four U-shaped blades having the open ends of the U attached to and starting approximately five inches from the base of the frustum. The four fins are located 90 degrees from each other.

A band of metal, 5 inches wide and 15 inches in diameter, is welded to the rear end of the fin assembly. This band serves to protect the fin blades against warpage caused by impact with the water and also protects the blades against damage in handling and assembly.

Arming Wire. The arming wire assembly for use with the AN-Mk. 224 Hydrostatic Bomb Fuze is type B which consists of a swivel loop or arming plate to which are attached two lengths of wire each approximately 20 inches long.

The arming wire assembly for use with the AN-Mk. 219 or AN-Mk. 221 Nose Bomb Fuzes is type A which consists of a swivel loop or arming plate and a single wire approximately 22 inches long.

Altitude and Speed of Release. Tests show that this bomb will function if released from altitudes up to 5,000 feet. However, when dropped from high altitudes, the hydrostatic fuze will function at a greater depth than that for which it is set. The minimum altitude to provide safety from blast in horizontal bombing is 100 feet.

If speed and altitude at release are such as to produce an angle of impact flatter than 20 degrees from horizontal, a ricochet is probable and if flatter than 15 degrees a ricochet may be expected.

Flat Nose Attachments. As stated above, ricochets may be expected with the round nose 325-pound AN-Mk. 17M1 Depth Bomb. Also, it has been found that deflection to the right or left from the course intended may result. To remedy this situation, flat nose attachments are issued so as to enable the bombs to be modified in the field. The attachments will greatly reduce the tendency of the bombs to ricochet at low altitudes and high speed. The 325-pound bomb, when equipped with flat nose attachments, may be dropped

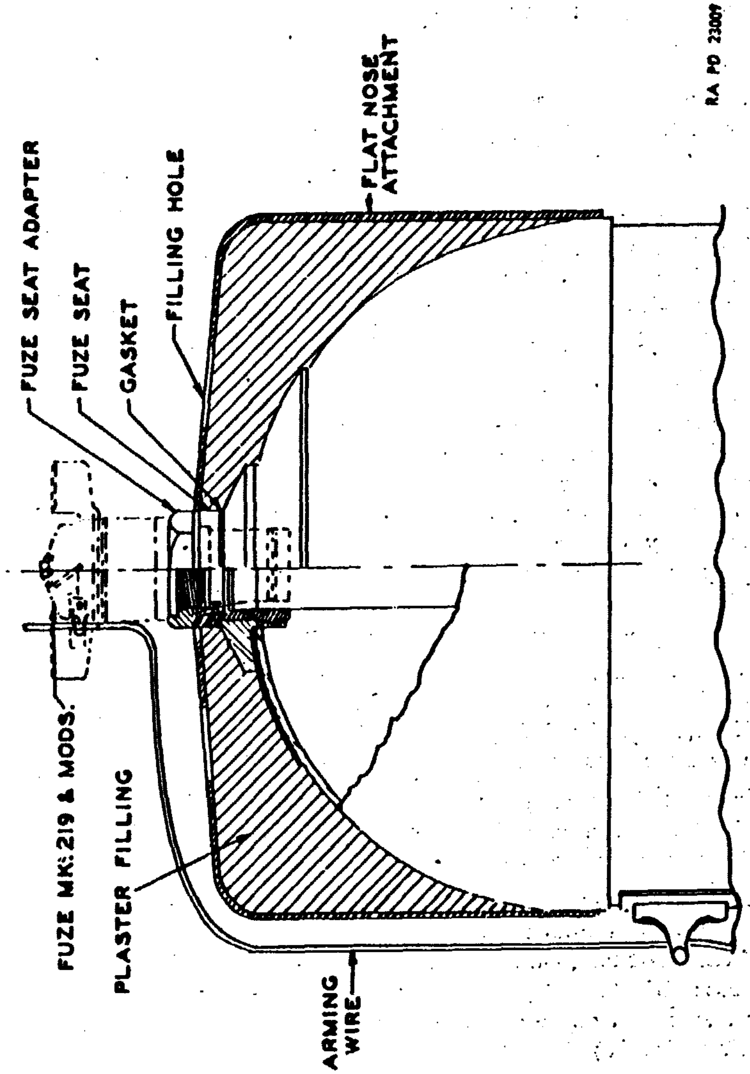


Figure 251 — Antiricochet Cap for 325-pound Depth Bomb AN-Mk. 17

at an altitude of 50 feet without appreciable danger or ricochet, provided the airspeed at release does not exceed 200 knots.

In general, the average horizontal component of the underwater travel to a depth of 25 feet will be between 30 and 40 feet, and the time of underwater travel to a depth of 25 feet will be between 2 and 4 seconds for the 325-pound depth bomb.

Tests have also shown that the depth bombs equipped with flat noses have considerably less tendency to deflect to the right or left of a normal course in underwater travel. Average deflections from the normal point of detonation (25-foot setting) are approximately 7 feet for the 325-pound depth bomb with a maximum of 15 feet occurring in some cases.

The air trajectories of the depth bomb will be slightly affected by the addition of the flat nose attachments. When aircraft bombs equipped with flat nose attachments are carried on external racks, some reduction in air speed due to increased drag of the flat noses will occur.

The flat nose attachment consists of a metal nose attachment which fits around the adapter of the Nose Fuze AN-Mk. 219 or the nose of the bomb itself. The metal attachment has openings in it to allow for the addition of a plaster filling which fills the space between it and the round nose of the bomb body. The entire bomb weight is increased by approximately 44 pounds, of which 34 pounds consist of the plaster filling and the other 10 pounds consist of the flat nose attachment.

Complete Round Description. The total length of this bomb is 52.48 inches and the diameter is 15 inches. The case is only 0.062 inch thick. The weight of the metal parts is 85 pounds while the TNT filler weighs 243 pounds. Total weight of this bomb is 325 pounds. Percentage of filler is approximately 75.8 percent.

Fuzes. This bomb is fuzed with the Transverse Fuze AN-Mk. 234. Substitute or alternate fuzes are the transverse AN-Mk. 224 or its modifications, or the Nose Fuze AN-Mk. 219 or AN-Mk. 221.

Complete Round Components. A complete round is made up of the following components:
BOMB, AN-Mk. 17M1, 325 lb (1)
Fin assembly (1)
Fuze, nose, or transverse (1)
Arming wire (1)

NEW 325- TO 350-POUND DEPTH BOMBS.

Following the development of 325-pound AN-Mk.17M1 Depth Bombs, a new series was issued. These new bombs differ only in the shape of the nose or in the kind of filler, or may differ in both of these ways. The difference in filler has caused an increased weight so that the bombs are described as 350-pound depth bombs. The flat nose as previously described was added to prevent ricochet. A summary of the bombs and the main differences are indicated in the following table.

Bomb Nomenclature	Shape of Nose	Bomb Racks	Filler
325 lb AN-Mk. 17M1	Round	External or Internal	TNT
325 lb AN-Mk. 17M1	Flat (special attachment)	Internal	TNT
325 lb AN-Mk. 41	Flat	Internal	TNT
350 lb AN-Mk. 44	Round	External or Internal	Torpex *
350 lb AN-Mk. 47	Flat	Internal	Torpex *

*44% cyclonite, 37% TNT, 18% powdered aluminum and 1% beeswax. Much more brisant than TNT.

BOMB, DEPTH, 650-POUND, AN-MK. 29.

General. The 650-pound depth bomb is used for undersea craft or surface vessels. It can be identified by the blunt nose, sheet metal case, and trunnion mounts, in addition to the double and single suspension lugs. The trunnion mounts are at the center of gravity and on opposite sides of the case 90 degrees from the double and single suspension lugs. The mounts are closed by a threaded plug. The trunnions are used to mount the depth charge on dive bomb suspension racks. When used with the AN-Mk. 224 Fuze, an extender is provided to make the fuze fit the longer transverse tube.

Description. Complete length of this bomb is 74.1 inches and the diameter is 17.07 inches. The bomb case is 0.125 inch thick. The metal parts of this bomb weigh 193 pounds while the explosive filler weighs 464 pounds. Total weight of this bomb is 657 pounds, 70.6 percent being explosive filler.

Fuzes. The standard fuzes provided for this bomb are the Tail Fuze AN-Mk. 229M1 and the Transverse Fuze AN-Mk. 234. Alternate fuzes are either nose or transverse. Those provided for the nose are the AN-Mk. 219, AN-Mk. 221, AN-M103, or M103. The alternate transverse fuze is the AN-Mk. 224 with its modifications. The M103 or AN-M103 must be equipped with special vane when used on flat-nose bombs. The standard vane will not cause the fuze to arm.

COMPLETE ROUNDS—DEPTH BOMBS

Weight and Designation	Filler	Fuze (Nose)	Fuze (Tail)	Fuze (Transverse)
325 lb AN-Mk. 17M1	243 lb TNT	AN-Mk. 219(1)	None	AN-Mk. 234(2)
325 lb AN-Mk. 41	TNT	AN-Mk. 219(1)	None	AN-Mk. 234(2)
350 lb AN-Mk. 44	TORPEX	AN-Mk. 219(1)	None	AN-Mk. 234(2)
350 lb AN-Mk. 47	TORPEX	AN-Mk. 219(1)	None	AN-Mk. 234(2)
650 lb AN-Mk. 29	464 lb TNT	AN-Mk. 219(3)	AN-Mk. 229	AN-Mk. 234(4)
650 lb AN-Mk. 37	TNT	AN-Mk. 219(3)	AN-Mk. 229	AN-Mk. 234(4)
650 lb AN-Mk. 38	TNT	AN-Mk. 219(3)	AN-Mk. 229	AN-Mk. 234(4)

(1) Fuze AN-Mk. 221 may be substituted. The adapter and one booster charge must be removed.
(2) Fuze AN-Mk. 224 or modifications may be substituted.
(3) Fuze AN-Mk. 221 or modifications or AN-M103 with special vane, may be substituted.
(4) Fuze AN-Mk. 224 or modifications may be substituted. An extender supplied with the bomb must be used when using the AN-Mk. 234 or AN-Mk. 224 in 650-pound depth bombs.

AMMUNITION INSPECTION GUIDE

FUZES USED IN DEPTH BOMBS

Fuze Designation	Position In Bomb	Booster In Fuze	Bomb for Which It Is Adapted	Method of Arming	Primer Detonator	Action on Impact
AN-M103(1)	Nose	Yes	650 lb	Arming Vane w/mech. del.	None	Selective, Nondelay or 0.1
AN-Mk.219	Nose	No	All depth bombs	Arming Vane w/mech. del.	None	Instantaneous
AN-MK221	Nose	No	All depth bombs	Arming Vane w/mech. del.	None	0.01 sec del.
AN-Mk.224	Transverse	Yes	325, 350, 650 lb	Arming Pin	None	Acts on water pressure
AN-Mk.229	Tail	?	650 lb	Arming Vane w/mech del.	None	Acts on water pressure
AN-Mk.234	Transverse	Yes	325, 350, 650 lb	Acts on water pressure	None	Acts on water pressure

(1) Special vane must be used when AN-M103 is used with flat nose bombs. The standard vane will not arm the fuse on such bombs.

BOMBS FOR AIRCRAFT

Complete Round Components. Components necessary to make a complete round of ammunition are the following:

BOMB, Mk. 29 650 lb, loaded (1)
Fin assembly (1)
Fuze, nose, transverse or tail (1)
Arming wire (1)

Comparison of 650-pound Depth Bombs.

Bomb Nomenclature	Shape of Nose	Shape of Base	Explosive Filler
650 lb AN-Mk. 29	Round	Round	TNT
650 lb AN-Mk. 37	Round	Flat	TNT
650 lb AN-Mk. 38	Flat	Flat	TNT
700 lb AN-Mk. 49	Flat	Flat	Torpex

FURTHER REFERENCES: A complete list of references regarding bombs may be found at the close of this section.

Chapter 5

Fragmentation Bombs

GENERAL.

Early Types. At the close of World War I the U. S. government had two fragmentation bombs which were designated the 17-pound Mk.II and the 25-pound Mk.III.

The 17-pound Mk.II was a modification of rejected 3-inch and 75-mm shells. Attached to the shell to convert it to a bomb was a fin assembly, a lug for horizontal suspension, and an adapter to provide for fitting a suitable fuze to the body. The fuze used was the Mk.XI arming pin type with the Mk.III Primer Detonator.

The 25-pound Mk.III Bomb was a pear-shaped bomb known as the British Cooper bomb. The body was manufactured from malleable iron or semisteel. It was stabilized in flight by use of a fin assembly. It utilized the Mk.XII Time Fuze, which could be set from 0 to 30 seconds in intervals of 5 seconds, in conjunction with the Mk.II Primer and the Mk.IV Detonator.

Both bombs were intended for high-altitude bombing. Both bombs are now obsolete.

Modern Design. Fragmentation bombs are used for the purpose of producing destructive effect against personnel and light material targets. To accomplish this, the bombs are so designed as to break into a large number of effective fragments of uniform size. Although the blast will do damage at the point of impact, most of the effect is achieved by the bomb fragments. To facilitate fragments of uniform size, the bomb body is constructed of a series of rings assembled over a tubular sleeve. Recently, a spiral spring of square cross section has replaced the rings. The width and thickness of the ring or spring determines the width and the thickness of the fragments. Attempts to predetermine a third dimension, the length of the fragment, by notching each spring has not been successful. The design entailed too much machining to make large scale production feasible. Since the bombs depend entirely upon fragmentation to produce desired effects, the case or body is comparatively heavy while the explosive charge is just enough to rupture the case. The weight of the high explosive in these bombs is about 12 to 15 percent of the total weight of the bomb.

Fragmentation bombs are considerably smaller than demolition bombs, making it possible for a greater number to be carried by a plane. Some foreign countries have fragmentation bombs of even smaller size.

Tests.

The pit test. In determining the fragmentation efficiency of bombs at the proving ground, three types of tests are conducted. The pit test, the low panel test, and the silhouette test. In the pit test, the bomb is placed in a wooden box and buried in a sand pit of suitable size, and detonated statically. The sand is then screened and the fragments recovered on four sizes of mesh, the openings varying from 0.165 to 0.838 inch. These fragments are carefully weighed, screened, and classified, and a decision as to the effectiveness of the bomb is obtained. Any of these sizes is considered an effective fragment. However, the more fragments, the better the bomb is considered to be.

The low panel test. The low panels consist of four quadrants of panels, 12 inches wide, 5.75 feet high and 0.82 inch thick, of spruce lumber. Each panel represents the height and width of a man. Quadrants of panels are placed 10, 20, 30, and 40 meters from the center at which the bomb is fragmented statically. By substituting either the total number of perforations counted or the number of panels perforated at the several distances in a formula, a figure is obtained which represents relative fragmentation effectiveness in terms of casualties over a definite area and with a definite and uniform distribution of personnel over this area.

Silhouette test. The silhouette test consists in dropping a bomb on a field of silhouettes spaced 15 to 45 feet apart. The silhouettes are of the same dimensions as the low panels and represent the height

and width of a man. The bombs are dropped from altitudes between 2,000 and 4,000 feet. The perforations of silhouettes within radii of 10, 20, 30, and 40 meters from the point of impact are counted and used in a formula to obtain a figure of effectiveness. This test is identical with the low panel test except that the bombs are actually dropped and fragment on impact rather than being set off statically. This brings in the effect of the forward motion of the bomb, angle from vertical at which impact occurs, and any delay in functioning, thus giving a measure of the actual performance of the bomb.

Results of tests. The results of various tests seem to indicate that the ring or spring 0.44-inch square is the best. The number of fragments from the entire bomb will vary between 1,000 and 1,500, although many of these are relatively ineffective. To obtain the most effect, the bomb must be exploded while its axis is as nearly vertical as possible. This is because the side spray may be directed into the ground or harmlessly dissipated in the air if the bomb detonates while at any appreciable angle from the vertical.

If a stabilized bomb is released from minimum altitudes, it will not strike the ground in an upright position which is desirable.

As a result of tests, a means of assuring the escape of the plane from bomb fragments and a means of having the bomb nearly vertical at impact has been devised by replacing the fin assembly with a parachute assembly. A specially designed fuze is used to initiate function of fragmentation bombs with this parachute attachment.

Effect of Fragments. The fragments from a fragmentation bomb are projected with a velocity of over 4,000 feet per second. Fragments weighing approximately 0.3 ounce have been projected to a distance of 600 yards. The average fragment has about the same bulk as a cal. .30 bullet. The side spray of a fragmentation bomb (if detonated in a vertical position) is much more effective than that of a shell of equal weight.

FUZE, Bomb, Nose, M104.

General. This fuze is of the arming pin type with time delay. It arms approximately 2.5 seconds after the arming wire is withdrawn. Its action on impact is instantaneous because this action is necessary for effective dispersion of fragments. The M104 is used in the 23-pound M40 or the 23-pound M72 Fragmentation Bomb. It is packed 1 per container, 50 per box.

Description. A mushroom-shaped striker assembly extends approximately 0.5 inch beyond the nose of the fuze body. The firing pin, supported by a spring which keeps it in contact with the striker assembly, is housed within the body of the fuze. The booster encased in an aluminum cup protrudes from the base of the fuze. A time

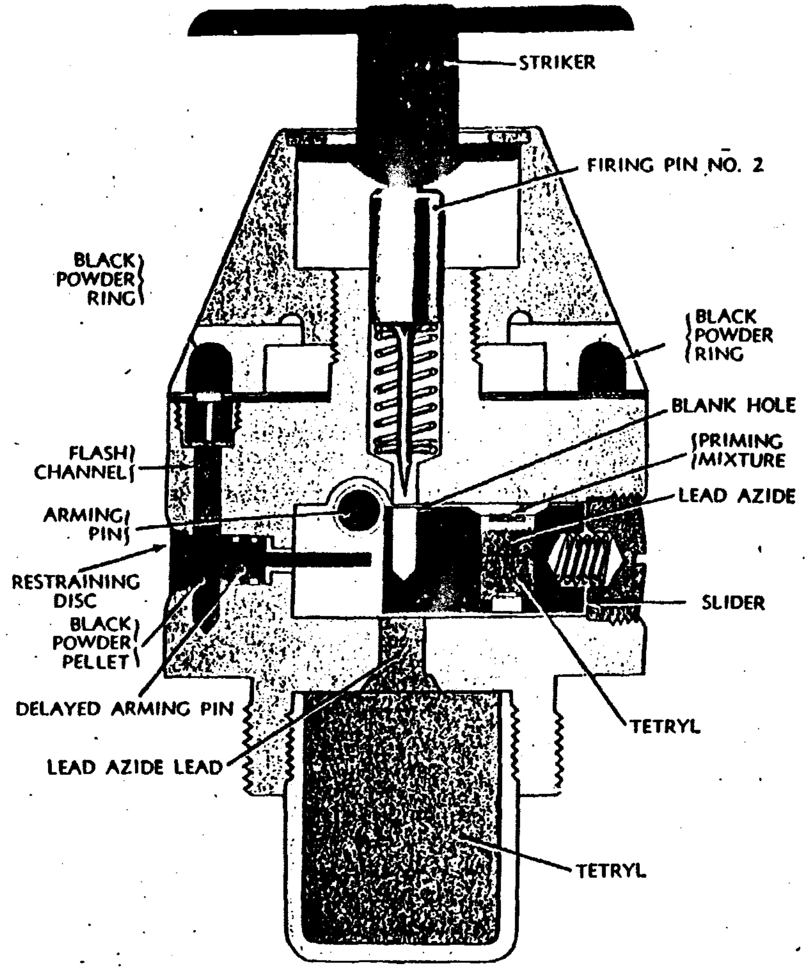


Figure 252 — FUZE, Bomb, M104 (Nose)

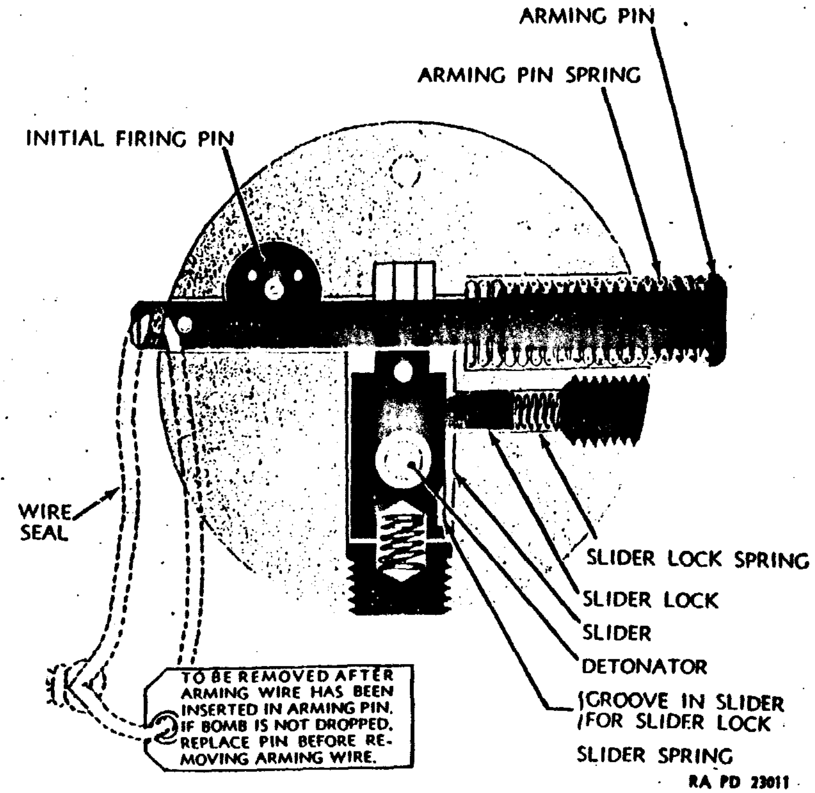


Figure 253 — FUZE, Bomb, M104 (Nose)—Cross Section

delay train located near the midpoint of the fuze provides for time delay in arming. The detonator is mounted in a slider located below the firing pin and is normally held out of the firing position by the arming pin which extends through the body of the fuze. Located in the slider is a blank hole for the protection of the firing pin when the fuze is in the unarmed position. In addition to the arming pin, a delayed arming plunger prevents the slider from moving to its firing position until the time delay train has burned through. When the time delay train has burned through, the delayed arming plunger is ejected and the slider moves to its armed position due to its spring. The time delay is initiated by an auxiliary firing pin which is driven forward by a compressed spring after the arming pin is ejected.

If armed, the fuze will function at any angle up to 13 degrees from the horizontal on striking the ground. If the fuze impacts the ground while the time train is still burning, it will not function on impact. If armed, the fuze will function on jarring and is exceedingly dangerous to handle.

Time delay is necessary because the parachute fragmentation bomb falls too slowly and from too low an altitude to use an arming vane with mechanical delay type of arming.

Function. The arming cord is withdrawn by the parachute, and the arming wire, which is tied to the arming cord, is withdrawn from the arming pin. The arming pin is ejected by its spring. Ejection of the initial arming pin leaves the slider held in the unarmed position only by the delayed arming pin. At the same time, the arming pin frees the cocked firing pin which is forced by its spring to strike the primer.

The flame from the primer ignites a loose charge of black powder which ignites the delay train. The gas from the burning black powder escapes from the fuze through vents in the upper part of the fuze body. The delay train burns for approximately 2.5 seconds and terminates in a small charge pellet of nitrocellulose. This ignites the body pellet which causes the explosion of a black powder charge around the delayed arming assembly.

The delayed arming assembly, consisting of a washer restraining disc and a plug, is forced out of the fuze body by the pressure created by the black powder. The slider, due to the action of its spring, is now free to move the delayed arming pin to the end of the fuze housing. In so doing, the slider brings the detonator directly underneath the firing pin, or into the armed position. The slider is locked in this position by a slider lock pin which rides in a groove in the side of the slider and fits into a cavity in the groove when the slider moves into the armed position.

Upon impact, the striker is forced inward causing the firing pin to move against its spring and strike the detonator. The detonator consisting of priming mixture, lead azide, and tetryl starts a shattering wave which functions a lead charge of lead azide. The lead charge in turn functions the booster charge of tetryl which is part of the fuze.

FUZE, Bomb, Nose, M109. There are but few differences between the M109 and the M104 described above.

The M104 is used on the parachute fragmentation bombs for low-altitude bombing. The M109 is used on the fin fragmentation bomb (20-lb M41) for medium low-altitude bombing (below 800 feet).

The M104 has a larger diameter striker head than the M109.

The M104 has the striker resting on the firing pin. The M109 has a striker spring cover and striker resistance spring underneath the cover to hold the striker in position. This is because the M109 has more wind pressure to counteract as it falls because of the height

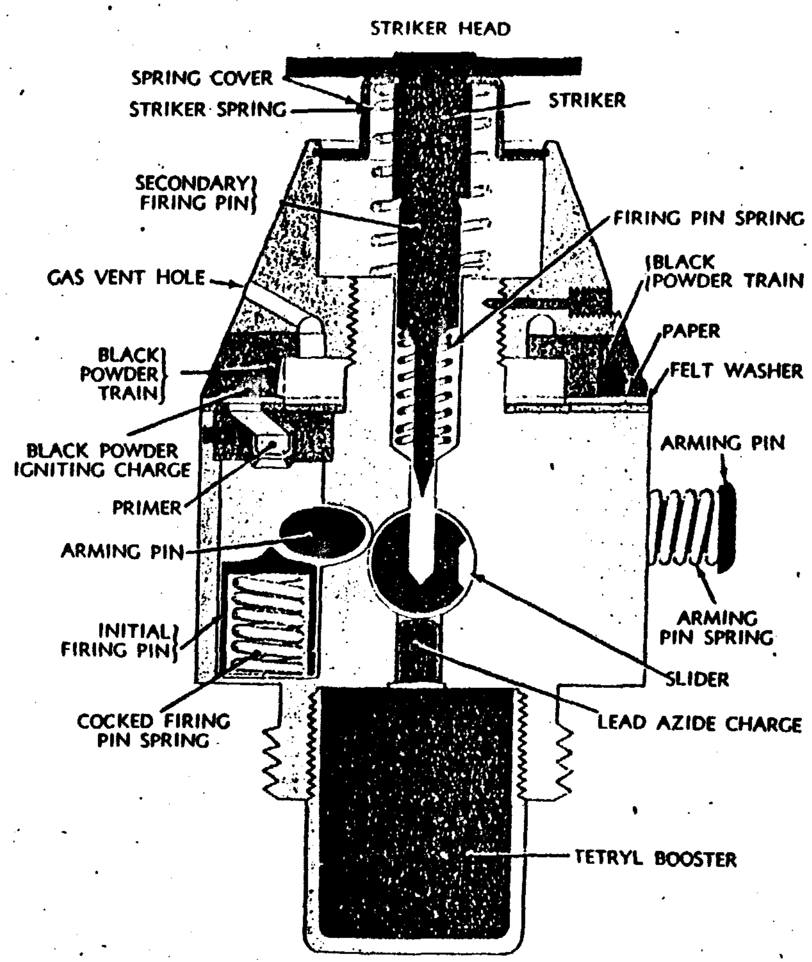


Figure 254 — FUZE, Bomb, M109 (Nose)

of fall and the speed of fall due to the absence of a parachute. The M109 might function before it struck if it did not incorporate this additional safety feature.

The M109 in all other features is similar to the M104. It is not generally used because the parachute fragmentation bomb is used for low-altitude bombing whereas the fin fragmentation bomb is usually used for high-altitude fragmentation bombing.

FUZE, Bomb, Nose, M120. Recently the M104 Fuze described above was replaced by the M120. The M120 is fundamentally the same fuze as the M104 except that its delay of 2.5 seconds in arming is produced by a mechanical time mechanism. It is more economical and easier to manufacture than the M104.

FUZE, Bomb, Nose, AN-M110A1.

General. This is an arming vane type of fuze with mechanical delay in arming. Its action on impact is instantaneous. The fuze is armed after approximately 340 revolutions of the vane. It is used in the 20-pound AN-M41 Fragmentation Bomb, the 20-pound M48 Practice Bomb, and the 115-pound M70 Chemical Bomb. It is packed 1 per container, 50 per box.

Description. The fuze is about 3.59 inches long and 2.30 inches of this length projects from the bomb when assembled. The vane is assembled to the fuze and has two tabs leading from it. These tabs have two holes which correspond to holes in a vane lock on the side of the body. These holes are to allow the fuze to be kept in the unarmed position until otherwise desired. The booster is encased in a metal cup which protrudes from the base of the fuze. On top of the booster cup is a metal disc with a small hole in the center to hold the detonator cup.

Above the detonator is the striker which is held away from the explosive element by a restraining spring and metal safety block. This unit is held in place by a small keeper.

The safety block is in the form of a ring with a section removed. This opening in the ring allows it to slip over the striker, but not over an arming sleeve which fits inside the safety block. When the vane revolves, the arming sleeve moves into the fuze housing by means of reduction gears, thereby freeing the safety block.

The reduction gears consist of a movable lower gear which is attached to the base of the arming sleeve. The arming sleeve is threaded into a ball race by means of 10 threads and so rotates with the arming vane. A stationary upper gear is attached to the ball race and, therefore, directly to the arming vane. Both gears are in mesh with an idler gear which is fixed loosely to a pin so that it can revolve around the axis of the pin.

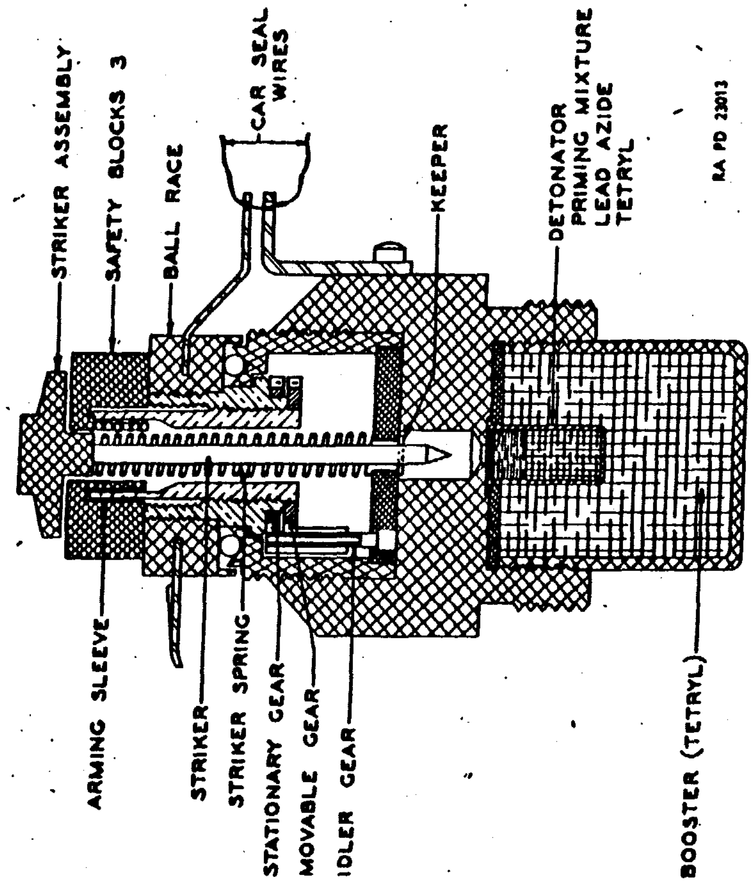


Figure 255 — FUZE, Bomb, M110 (Nose)

The movable gear has 34 teeth and the stationary gear has 33 teeth. Both gears turn with the arming vane. Both gears are in mesh with the idler gear and because of the differential in teeth, for every rotation of the arming vane the movable gear gains one tooth and the arming sleeve turns 1/34 of a thread. For every 34 revolutions of the vane, the movable gear gains 1 complete turn and the arming sleeve turns 1 thread. As there are 10 threads to be turned before the arming sleeve moves completely into the fuze housing, 340 turns of the arming vane are required to arm the fuze.

Function. The cluster is dropped and the arming wire is retained in the plane. The cluster opens and the bombs fall free. The arming vane begins to rotate and, through a set of reduction gears, slowly moves the arming sleeve into the fuze housing. After approximately 340 revolutions of the arming vane, the sleeve moves completely into the fuze housing allowing the safety block to fall free, arming the fuze. The striker is now held away from the detonator only by a restraining spring.

Upon impact, the striker is forced inward against its spring causing the firing pin to strike the detonator of priming mixture, lead azide, and tetryl. The wave produced functions the booster of tetryl which is part of the fuze.

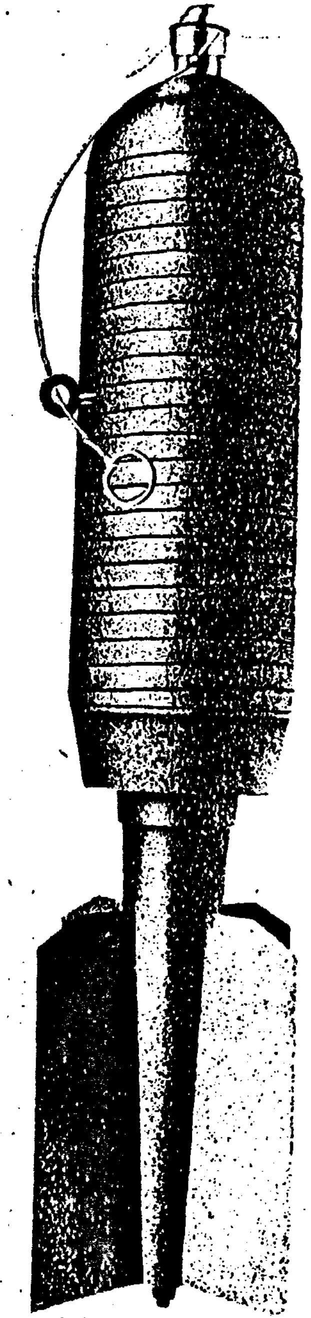
FUZE, Bomb, Nose, M110.

General. There are several differences between the M110 and the AN-M110A1 Fuzes, although the latter is the result of modifications made on the M110.

The AN-M110A1 is of much heavier construction, is larger in body shape although it has a smaller striker head. The vanes are smaller but wider and the entire body is treated with chromate solution to permit greater resistance to rust and corrosion. In general, it can be stated that the construction is much sturdier.

The AN-M110A1 has one safety block, split-ring shaped, and an arming sleeve which fits inside the safety block. The M110 had three safety blocks with inner recesses which slipped around an arming sleeve. If, as in certain cases, the arming sleeve was partially in the armed position, the safety blocks of some of the fuzes examined were found missing or almost off the arming sleeve. Such situations could and did result in serious accidents. All of the M110 fuzes were removed and were returned to the manufacturing plant for modification.

The AN-M110A1 has a reduction gear ratio which will allow the fuze to arm in 340 rotations of the arming vane, whereas the M110 has a ratio which allows the fuze to arm in 570 rotations of the arming vane.



RA PD 23014

Figure 256 — 30-pound Fragmentation Bomb M5, With Mk. XIV Nose Fuze

BOMB, FRAGMENTATION, 30-POUND, M5.

General. This bomb was designed to have uniform effective fragments. It is standard for issue only, supplanted by a smaller bomb which is as effective and more economical. It is intended for high-altitude fragmentation bombing against such targets as personnel, motor convoys, planes on the ground, etc.

Bomb Body Description. The body consists of an inner steel sleeve which is threaded on both ends. Assembled over the sleeve is a series of steel rings which was cut from seamless steel tubing. The width and thickness of the individual rings determines the size of the fragments. A very even distribution of fragments of uniform size can be obtained. As an alternate to the rings, a closely wound helix bar of steel which is cheaper and just as effective is sometimes used.

The steel rings or helix bar of steel are held in place by two end adapter forgings which are screwed into the threads of the inner steel tube. The nose adapter is threaded to receive the M26 Adapter Booster. The M26 Adapter Booster in turn receives the Mk.IIB Primer Detonator and the Mk XIV Fuze. The tail adapter is closed and has a threaded protrusion to receive the fin assembly.

Two suspension lugs are provided, one welded to the bomb body for horizontal suspension and the other threaded to the fin assembly for vertical suspension.

The filler consists of 4.5 pounds of TNT, about 15 percent of the total weight of the bomb.

Fuze Mk. XIV. Brief mention can be made of this fuze as it is of relative unimportance today. It is the arming vane type, arming after several revolutions of the vane. The vane cup which moves up with the vane on arming frees a series of metal balls which permit the striker to be held off the fuze housing only by a shear wire.

The instantaneous primer detonator, the Mk.IIB, is a separate component consisting of primer, black powder, mercury fulminate, and tetryl. It is quite sensitive and dangerous to handle. On impact, the firing pin functions the primer detonator which in turn functions the M26 Tetryl Booster which functions the TNT charge in the bomb body.

The use of this fuze was dangerous because it armed so quickly and functions instantaneously on impact. If dropped singly, the fuze's arming so quickly may function the bomb directly beneath the plane due to accidental impact.

BOMB, FRAGMENTATION, 20-POUND, AN-M41.

General. This bomb is designed to replace the 30-pound M5 Fragmentation Bomb complete with stabilizing fins and fuze. It weighs 20 pounds and yields fragments equal to those of the 30-

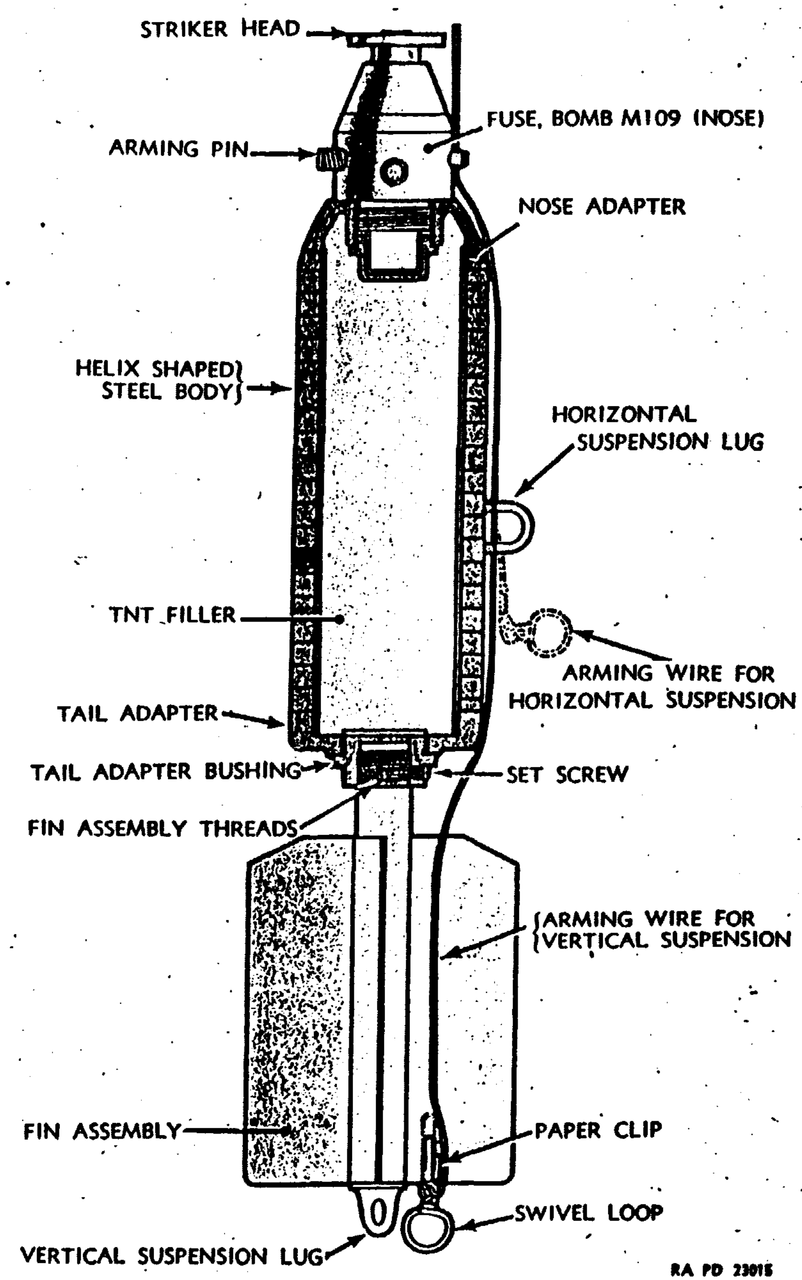


Figure 257 — BOMB, Fragmentation, 20-pound, M41

pound bomb in both size and destructive effectiveness. It is intended mainly for high-altitude and occasionally for medium low-altitude bombing, depending on the fuze, against such targets as personnel, motor convoys, planes on the ground, etc.

Bomb Body Description. The body consists of an inner tubular steel sleeve which is threaded on both ends. Assembled over the sleeve is a closely wound helix bar of steel whose width and thickness will determine the size of the fragments. A very even distribution of fragments of uniform effective size can be obtained.

The helix bar is held securely in place by two end adapter forgings screwed into the threads of the inner sleeve. The nose adapter is internally threaded to receive the Nose Fuze AN-M110A1 or M109 and a fuze well cup. The tail adapter is closed and has a threaded protrusion to receive the fin assembly.

Suspension lugs, one for horizontal suspension is welded on the bomb body, the other for vertical suspension is attached to the tail end of the assembly. The filler consists of 2.7 pounds of TNT or approximately 13½ percent of the total weight of the bomb.

Fin Assembly. The fin assembly consists of steel pipe threaded at one end to screw into the bushing of the rear adapter. It is held in place by a set screw when assembled. Attached to the pipe are four blades, and at the rear end a suspension lug is attached for vertical suspension.

When assembled to the bomb body, the fin is so assembled that one fin blade will be in line or at an angle of 45 degrees to the horizontal lug on the bomb body.

BOMB, FRAGMENTATION, 20-POUND, M42.

General. This bomb in construction is exactly the same as the 20-pound AN-M41 previously described. However, it is used against invading bombardment formations. For this purpose, the only change in the complete round is a change in the fuze from AN-M110A1 to the T7E1 which is a mechanical time and impact fuze.

This bomb is still in the experimental stage not in so far as the bomb body or fin assembly is concerned, for it has the standard body and fin assembly, but in so far as the fuze is concerned. The difficulty arises in timing the fuze so as to function the bomb near the proper place to produce effective fragments. At the present time, this model bomb is not included in the Standard Nomenclature Lists (January 1, 1943).

BOMB, FRAGMENTATION, 23-POUND, M40.

General. The Air Forces introduced a new tactical use for fragmentation bombs in which the bombing was to be done from very

low altitudes in order that the screening effect of trees and low hills might be used to hide the approach of attacking planes. Extensive tests were conducted; it was found that usually the plane was not far enough away to be out of the danger zone when the bomb exploded and also that the bomb would usually function in a horizontal position so that a loss of efficiency would occur. At times, the bomb failed to function at all.

It was evident, therefore, that two factors had to be considered. The bomb must be retarded so that the plane would have time to leave the danger zone of the fragments before the detonation occurred. Also, it must function while its long axis was perpendicular to the ground.

The most practical way to accomplish this was to equip the bomb with a small parachute housed within a case occupying little more space than the stabilizing fins of the high altitude bomb. The 23-pound M40 Bomb was thus developed. The parachute serves to retard the descent of the bomb for the required time and causes it to strike with its axis nearly vertical.

The use of a fuze with a semi-all ways percussion head and instantaneous action on impact insures function before the bomb loses its vertical position and even though it strikes the target at an angle while swinging, pendulum-like, from its parachute. A delay in arming incorporated in the fuze prevents premature detonation of the bomb due to malfunction of the parachute or collision during flight.

Bomb Body Description. This bomb uses the same body as the 20-pound AN-M41 and M42 Fragmentation Bombs. It is equipped with a parachute, however, in place of a fin assembly. The fin assembly is removed and the same bushing that receives the fin assembly now receives the parachute assembly. It is kept securely attached to the bomb body by a set screw in the same manner as is the fin assembly. It uses the M104 or M120 Nose Fuze. The additional weight of the bomb is produced by the parachute assembly.

Parachute Assembly Description. The parachute case is cylindrical in shape. It is made of sheet metal. Inside the parachute case are two cardboard pilot discs which are attached by means of silk cord to the top of the parachute. The parachute is made of mercerized cotton and airplane fabric and is 8 feet in diameter. It is attached to the parachute case by 12 silk shrouds which are tied to an eye in the base of the parachute case. Tied to the lower ends of the shroud lines is a silk cord known as the arming cord. It extends through an opening in the base of the parachute case and terminates in a short length of arming wire which is inserted in the arming pin of the fuze.

Earlier models of this bomb were designed to be dropped singly. Later without changing the model number of the bomb, the bomb

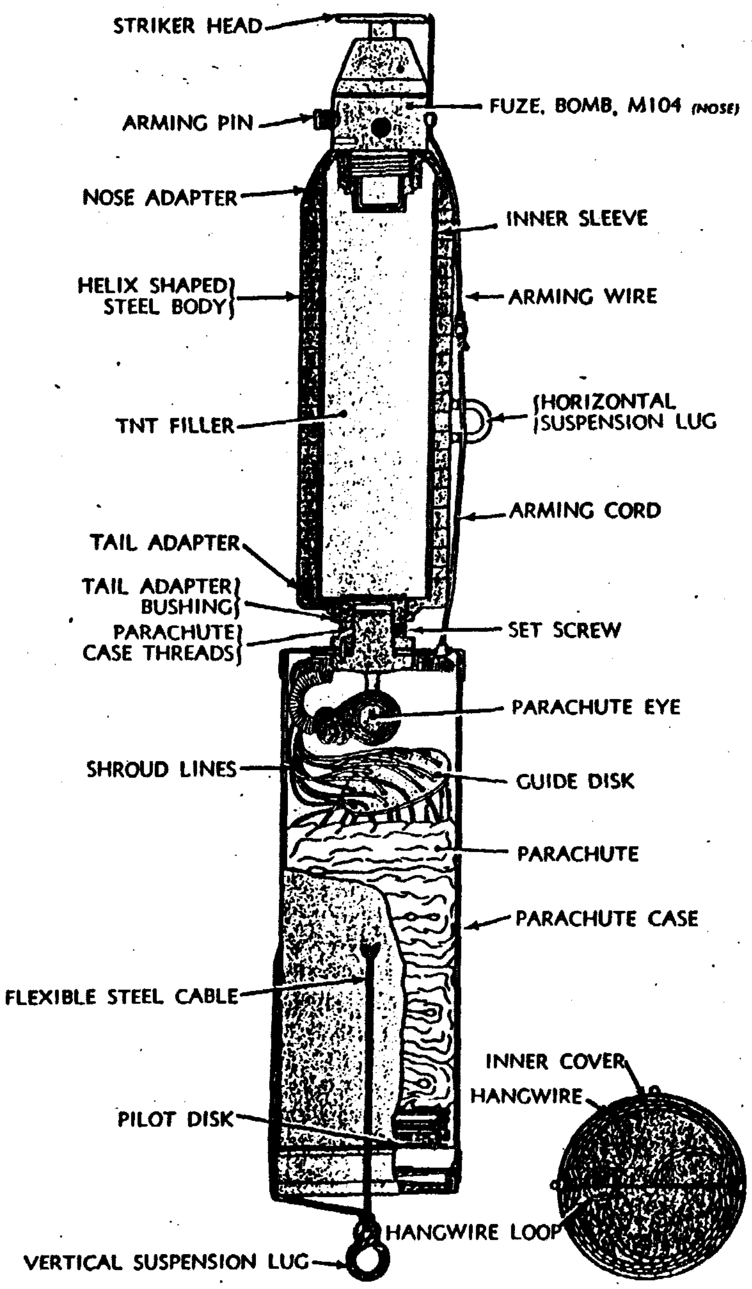


Figure 258 — BOMB, Fragmentation, 23-pound, M72

was modified to be dropped from clusters. The description of the above bomb is that of the later models.

Function of Parachute Assembly. The cluster is dropped and the arming wire is retained in the plane. The cluster opens and the outer cover is carried off the parachute case by the wind stream. The pilot discs are lifted out of the case by the air stream and in so doing withdraw the parachute from the case. As the parachute is filled with air, it retards the forward motion of the bomb and the arming cord is drawn into the parachute case and the arming wire is withdrawn from the arming pin of the fuze.

BOMB, FRAGMENTATION, 23-POUND, M72.

General. This bomb is the old 23-pound M40 Bomb used for single suspension only. The 23-pound M40 at one time was used for single suspension racks to be dropped unclustered. It was decided to change the 23-pound M40 in order to be able to drop these bombs from clusters. Without changing the model number, all of these bombs were modified to function from clusters. Included in the modification was the elimination of the outer cover and replacing it with the outer cover of the cluster, and the elimination of the inner cover, hangwire, and tear wire.

It was found that certain planes could not be adapted to receive the clustered parachute fragmentation bombs and could make effective use of parachute fragmentation bombs singly suspended. It was therefore decided to manufacture the old 23-pound M40 Parachute Fragmentation Bombs once again. However, to avoid confusion between the old and the new, the singly suspended parachute fragmentation bombs received the nomenclature "Bomb, Fragmentation, 23 pound M72."

Description. The body is the same as described for the 23-pound M40. The fuze used is the same, either the M104 or the M120 Nose Fuze. The parachute assembly in outward appearance is the same. It has attached to two points on the side, a flexible steel cable ending in a suspension loop above the case for vertical suspension.

The parachute assembly differs in the inside. After removing the outer cover, a flexible steel cable (hangwire) having a loop at one end and attached to an inner metal cover at the other end will be found. The loop on the cable is assembled to the bomb shackle in the same position as the arming wire. The inner cover which is held snugly in the parachute case has on its inner side a tear wire which is attached to the top pilot disc. From this point, both parachute assemblies are the same.

Function of Parachute Assembly. The bomb is dropped and the hangwire is retained in the plane. This pulls the inner cover from the parachute case. The inner cover, by means of the tear wire, pulls with it the top pilot disc. By means of a connecting cord, the top pilot disc withdraws the lower pilot disc and parachute. As the parachute is filled with air, it retards the forward motion of the bomb. The tear wire is torn, freeing the top pilot disc from the inner cover and thus severing any connection between the bomb and the plane. At the same time, the arming cord is sharply withdrawn from the arming pin of the fuze.

CLUSTER, FRAGMENTATION BOMB, M1 (100-POUND SIZE).

General. In order to provide for flexibility, fragmentation bombs are assembled into clusters. This serves for two definite advantages: the cluster may be installed in aircraft equipped with racks for large bombs; and clusters cover a large area more adequately than does the same number of bombs released singly.

The complete assembly consists of the following components:

Adapter Cluster M1
BOMB, fragmentation, 20-pound, M41 (6)
FUZE, bomb, M110 or AN-M110A1 (nose) (6)
Steel wires (4)
Cartridge M6
Firing mechanism M1
Wire, arming, type A

Adapter Cluster M1. The adapter cluster serves as the framework for holding the bombs together. It consists of two longitudinal steel tubes, a barrel, and separator. Welded to the separator and barrel are two nose and two fin supports for six bombs. Welded to the separator are two vane stops to prevent motion of the fuze vanes.

The barrel is hollow and is pierced with four holes through which four steel tie wires are threaded. The steel tie wires encircle the six bombs and hold them securely in place. One end of the barrel is closed with a steel plug. The other end seats a Cartridge M6 and is externally threaded to receive the M1 Firing Mechanism. Welded to the barrel are two loops 14 inches apart which act as double suspension lugs to fit into bomb racks that receive 100-pound bombs.

Firing Mechanism M1. The firing mechanism consists of a housing which contains a cocked firing pin. The lower portion is internally threaded to screw onto the barrel of the adapter cluster. The firing pin has two holes, one for a cotter pin and the lower one for the car seal wire which is replaced by the arming wire on assembly in the plane.

Cartridge M6. This consists of a primed cartridge case carrying a small propelling charge of 6 grains of black powder. The mouth of the cartridge case fits around a steel slug and the cartridge case is

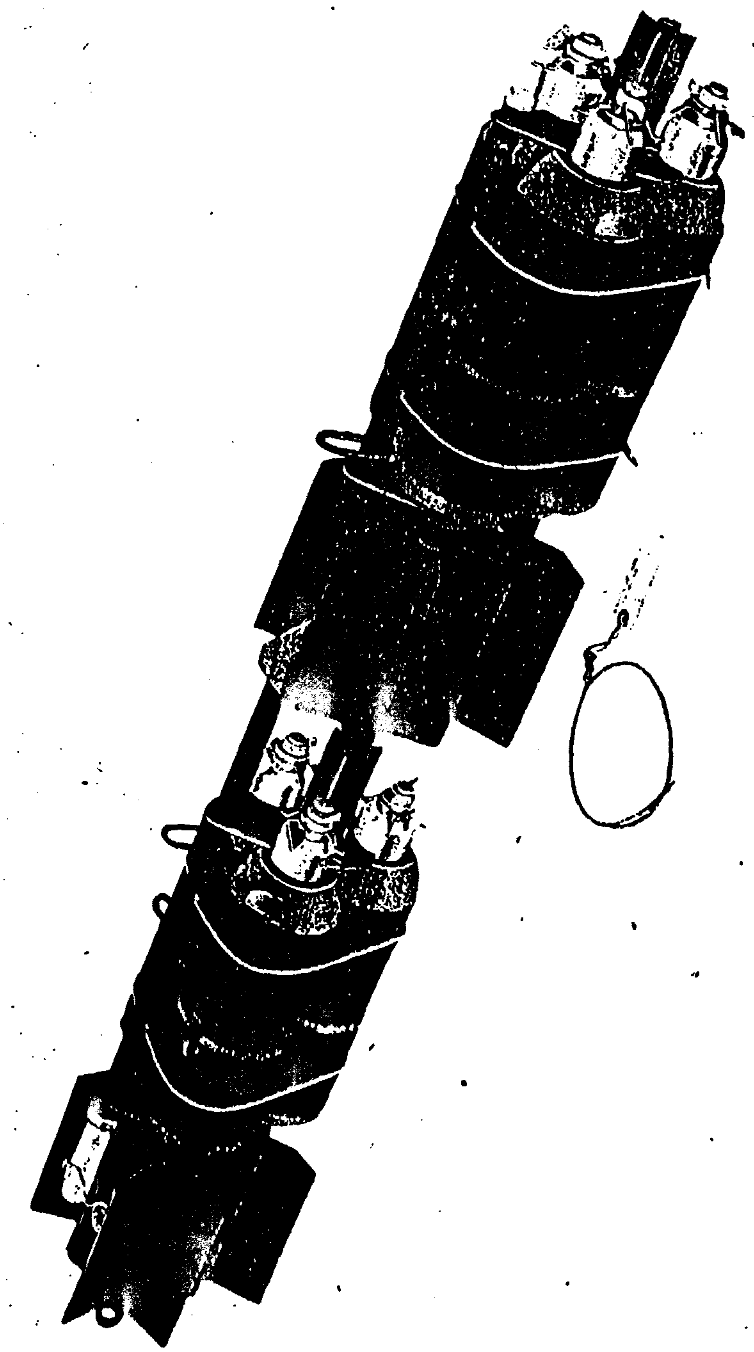


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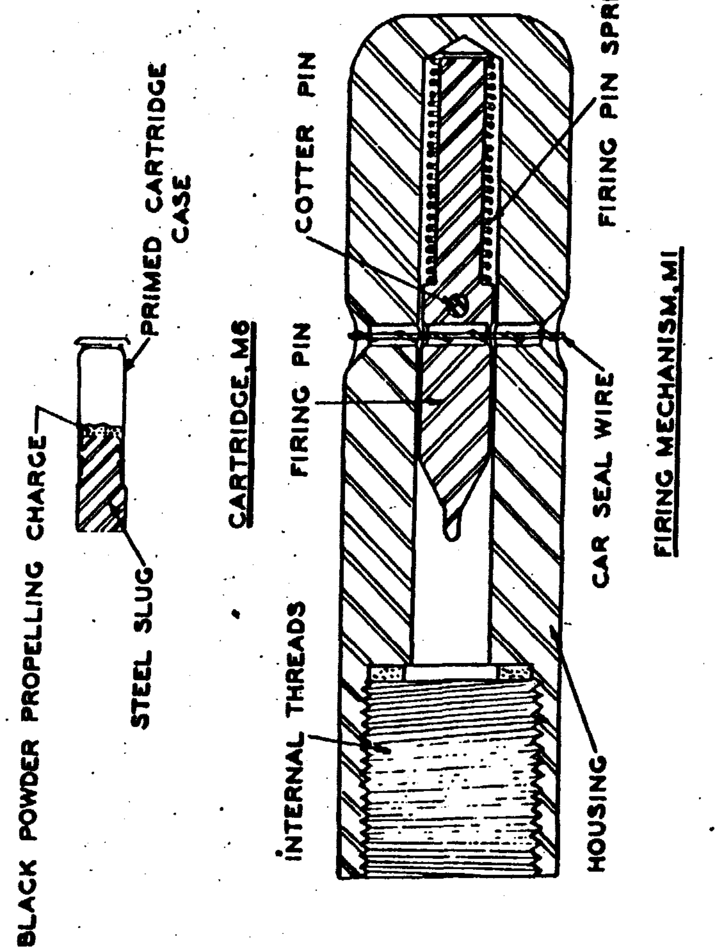
Figure 259 — Fragmentation Bomb Cluster



RA PD 23017

Figure 260 — Firing Mechanism and Cartridge for Fragmentation Bomb Cluster M1

held to the slug by crimping. The steel slug has sharp corners for severing the tie wires.

BOMB, Fragmentation, 20-pound, M41. In this fragmentation, cluster six 20-pound Fragmentation Bombs M41 are used. These bombs are fuzed with M110 Nose Fuze or AN-M110A1 Nose Fuze. The bombs are held in place by the four steel tie wires, resting on the adapter cluster by means of the nose and fin supports which allow for a snug fit.

Function. The fragmentation cluster is dropped and the arming wire is retained in the plane. This allows the firing pin due to the action of its compressed spring to strike the primer of the cartridge. The primer ignites the black powder propelling charge which propels the steel slug down the barrel of the adapter cluster. The slug, as it passes through the barrel, severs the four steel tie wires allowing the bombs to fall free and the vanes to begin to rotate. The steel slug terminates in a steel plug at the end of the barrel. Also at the end of the barrel is a large hole pierced in one side to allow for the escape of gas at that point.

If dropped safe, the arming wire is dropped with the cluster. The cartridge is not fired nor are the bombs released from the cluster. The vane stops restrain the fuzes from arming and the bombs do not function on impact.

CLUSTER, FRAGMENTATION, BOMB, M3 (100-POUND SIZE).

General. This cluster is similar to the M1 previously described. The components differ, but in function it is similar except in the incorporation of a delay cartridge of 5 seconds. This cartridge permits the cluster to drop for 5 seconds before opening. This delay is essential because the fuzes used with the fragmentation bombs in this cluster arm after several rotations of the arming vane. This delay permits the bombs to be well out of the range of the bomb fragments in the event that the bombs accidentally function in the air upon arming of the fuze.

The complete assembly consists of the following components:
Adapter Cluster M2
BOMB, fragmentation 30-pound, M5 (6)
FUZE, bomb, Mk.XIV (nose) (6)
Primer Detonators, Mk.IIB or Mk.IIC, instantaneous (6)
Steel wire (4)
Cartridge M7
Firing mechanism M1
Wire, arming, type A

Adapter Cluster M2. This adapter cluster is the same as the M1 previously described. Fundamentally, it differs only in size. It is larger for it receives the larger 30-pound fragmentation bomb instead of the smaller 20-pound fragmentation bomb. It is designed for 100-pound bomb racks.

Firing Mechanism M1. This is the same mechanism as previously described.

Cartridge M7. This consists of a primed cartridge case containing an igniter of black powder, a 5-second delay of black powder, a relay of black powder and a propelling charge of black powder. The mouth of the cartridge case fits around a steel slug and is held in place by crimping.

BOMB, Fragmentation, 30-pound, M5. In this fragmentation cluster, six 30-pound Fragmentation Bombs M5 are used. These bombs are fuzed with Mk.XIV Nose Fuzes using the Mk.IIB or Mk.IIC Instantaneous Primer Detonator. The bombs are held in place by four steel tie wires, resting on the adapter cluster by means of the nose and fin supports which allow for a snug fit.

Function. The fragmentation cluster is dropped and the arming wire is retained in the plane. This allows the firing pin due to the action of its compressed spring to strike the primer of the cartridge. The primer ignites a black powder igniter charge which ignites the delay of black powder that burns for 5 seconds. The delay of black powder ignites a relay charge of black powder and that initiates the propelling charge of black powder. The propellant sends the steel slug down the barrel of the cluster causing the slug to sever the four tie wires and to set the bombs free. The bombs fall free of the cluster and the vanes begin to rotate. The steel slug terminates in a steel plug at the end of the barrel. Also at the end of the barrel is a large hole pierced in one side to allow for the escape of gas at that point.

CLUSTER, FRAGMENTATION, BOMB, AN-M1A1 (100-POUND SIZE).

This cluster has been designed to replace M1 Fragmentation Bomb Cluster. It is simpler in construction and operation and utilizes a mechanical releasing device in place of a firing mechanism and cartridge to release the bombs from the cluster.

Components necessary to make a complete round:

Adapter Cluster AN-M1A1
BOMB, fragmentation, 20-pound AN-M41 (6)
FUZE, bomb, AN-M110A1 (nose), (6)
Steel, band (2)
Wire, arming, type B

Adapter Cluster AN-M1A1. This cluster consists of two longitudinal hollow steel tubes which can be described as a barrel and separator, the barrel being wider in diameter than the separator. Welded to

the barrel and separator are two nose supports and fin supports for six bombs. Welded to the separator are two vane stops to prevent motion of the fuze vanes. Passing through slits in the nose and fin supports near the separator are two flat pieces of spring steel formed in such a manner that when the bombs are pressed against them the resulting tension will force the bombs out of the cluster when the cluster opens.

Around the barrel will be found three suspension lugs, the outer two being 14 inches apart for double suspension, the inner one being exactly between the outer two at the center of gravity for single suspension. Any of these lugs can be removed from its extended position by withdrawing a cotter pin and bolt which holds them extended. The lugs will now be in such position that the bolt which formed the point for suspension will be in contact with the barrel.

Welded to the barrel approximately 5 inches from the outermost lugs are two clasp holders. Each clasp holder consists of two metal pieces, each piece having a hole at one end for a screw bolt of a steel band to fit through. The steel band has a clasp at its other end and will encircle the bombs, thereby holding them in place, so that the clasp will fit into the clasp holder. Four small holes pierced through the clasp holder at a point somewhat above the two main holes allow for the insertion of a common safety wire and arming wire.

As there are two clasp holders and two steel bands, the arming wire and safety wire pass through the two holders and when removed, the pressure of the bombs against the steel bands and the spring tension of the steel bands forces the bands with their clasps to spring open and free the bombs. The adapter cluster is designed for 100-pound bomb racks.

BOMB, Fragmentation, 20-pound AN-M41. This bomb is the same as the 20-pound M41, the AN merely being used to indicate that both services can utilize the bomb and cluster. The bombs, six in all, are held in place by the two steel bands which encircle the cluster. They rest on the adapter cluster by means of nose and fin supports which allow for a snug fit and are always being forced outward away from the cluster by the two flat spring steel pieces. The fuze used is the AN-M110A1.

Function. The cluster is dropped and the arming wire is retained in the plane. The clasps, which are now free, are sprung out of their holders by the pressure of the bombs against the steel bands and by the spring tension of the bands, freeing the bombs. The bombs are aided in their release from the adapter cluster by means of two flat spring steel pieces which eject them from the adapter. When the bombs are free from the cluster, the vanes begin to rotate and the fuze begins to arm.

CLUSTER, FRAGMENTATION BOMB, M4.

General. This cluster was designed to enable the dropping of parachute bombs from a cluster. The 23-pound Fragmentation Bombs M40 were all modified without change in nomenclature to enable them to be dropped from a cluster. Tests conducted at Aberdeen in October of 1942 proved that the cluster would function satisfactorily. However, a difference in position of cluster was noticeable in function. When the clusters were dropped with the nose end forward in the rack, 4 out of 36 bombs failed to function. When the clusters were dropped with the parachute end forward in the bomb rack, none of the 24 bombs tested failed to function.

Components necessary to make a complete assembly for this cluster are the following:

Adapter Cluster M3
BOMB, fragmentation, 23-pound M40 (3)
FUZE, bomb, M104 or M120 (nose) (3)
Steel, band (2)
Wire, arming, type B

Adapter Cluster M3. This adapter cluster is similar in construction to the AN-M1A1, although smaller. It consists of two longitudinal hollow tubes which can be described as a barrel and separator, the separator being smaller in diameter but about ½ foot longer than the barrel. Welded to both tubes is a rear end plate support for the parachute assembly, two parachute assembly supports, a support for the point of attachment of the parachute assembly and bomb body, and finally a bomb body support.

The barrel is the same in general construction and components as the adapter cluster barrel for the AN-M1A1. It has three lugs and two clasp holders attached in the same manner as previously described.

Attached to the parachute supports below the separator are two bolts. Around these bolts are coiled spring wires. Also attached to the bolts are partially cylindrical metal plates in which the three parachute assemblies are partially encased. The pressure of the parachute assemblies forces these plates against the coiled spring wire onto the parachute assembly supports. This causes the compressed springs to eject the parachute assemblies and, therefore, the bomb, when the cluster opens.

Two bolts are found protruding near the separator attached to the body supports. Around these bolts are spring coil wires against which the bomb body will press in order to rest on its support. These compressed springs will also aid in the ejection of the bomb body when the cluster opens.

COMPLETE ROUND CHART FOR FRAGMENTATION BOMBS

Weight, Designation and Status	Filler	Fuze (Nose)	Primer Detonator	Nose Adapter Booster	Tail Assembly
30 lb M5 (S)	4.51 lb TNT	Mk. XIV	Mk. IIC[1]	M26	Fin
20 lb AN-M41 (S&M)	2.7 lb TNT	AN-M110A1[2]	None	None	Fin
20 lb M42	2.7 lb TNT	T7E1	None	None	Fin
23 lb M40 (S&M)	2.7 lb TNT	M120[3]	None	None	Parachute
23 lb M72 (S&M)	2.7 lb TNT	M120[3]	None	None	Parachute

(1) Primer Detonator Mk. IIB may be found used.
(2) Fuze M109 or M110 may be found used.
(3) Fuze M104 may be substituted.

FUZES USED IN FRAGMENTATION BOMBS

Fuze Designation	Position In Bomb	Booster In Fuze	Bomb for Which It Is Adapted	Method of Arming	Primer Detonator	Action on Impact
M104	Nose	Yes	23 lb Parachute	Arming Pin w/time del.	None	Instantaneous
M109	Nose	Yes	20 lb Fin	Arming Pin w/time del.	None	Instantaneous
AN-M110A1	Nose	Yes	20 lb Fin	Arming Vane w/mech. del.	None	Instantaneous
M120	Nose	Yes	23 lb Parachute	Arming Pin w/mech. time del.	None	Instantaneous

Around the tail end of the parachute assembly and in contact with the rear end plate support will be found three covers in place of the outer covers of the parachute assemblies. These covers are the same in diameter, but differ in length. The longest is 4 inches; the next is 2 inches, and the smallest is ½ inch in length. These covers fall off the parachute assembly at different points in the bomb drop, the smallest freeing its parachute first, the longest freeing its parachute last, preventing the parachutes and bomb from interfering with each other.

The parachute fragmentation bombs are held in the adapter cluster by means of two steel bands and clasps in the same manner with the use of the same type arming wire and common safety wire as previously described.

BOMB, Fragmentation, 23-pound, M40. In this fragmentation cluster, three 23-pound Fragmentation Bombs M40 are used, the parachute fragmentation being much longer and heavier than the fin fragmentation bombs. These bombs are fuzed with the M104 Nose Fuze or the M120 and are held in place by two steel bands, resting on the adapter cluster by means of supports.

Function. The cluster is dropped and the arming wire is retained in the plane. The clasps, which are now free, are sprung out of their holders by the pressure of the bombs against the steel bands and the spring tension of the bands, freeing the bombs. The bombs are aided in their release from the adapter cluster by means of compressed springs which eject them from the adapter. When the bombs are free from the cluster, the outer covers fall off at different points in the bomb fall allowing the parachute discs to be exposed and the parachutes to open. The parachutes, as they open, pull the arming cord into the parachute case. The arming cord carries with it the arming wire which frees the arming pin allowing the fuze to arm.

FURTHER REFERENCES: A complete list of bomb references can be found at the close of the final chapter in this section.

Chapter 6
Chemical Bombs

GENERAL.

Development. For several years after World War I, no attention was directed toward the development of chemical bombs except for demonstration purposes. For this use, a 50-pound Mk.I with a smoke filler of FM was used. The bomb was made from the 40-

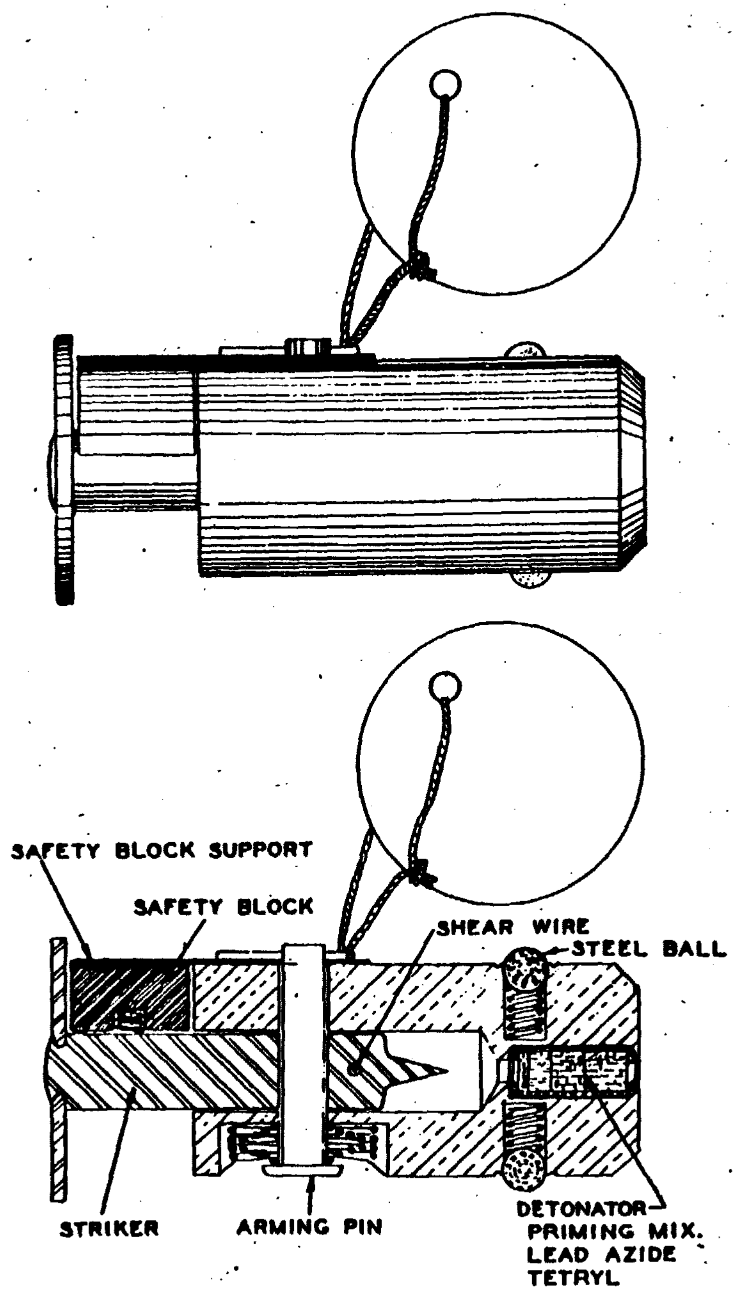


Figure 261 — FUZE, Bomb, M108 (Nose)

pound Mk.I incendiary which was streamlined in shape. A full length black powder burster with the Mk.XIV Fuze was provided.

With the trend toward the development of a chemical bomb being initiated, a general requirement that the bomb case must be strong enough to withstand "safe dropping" on normal soil from a height of 7,000 feet was decided upon.

This led to the development and standardization of the 30-pound M1 Chemical Bomb. This bomb was made by swaging a length of seamless steel tubing to a streamlined shape, fully closed at the tail end. A full length burster well was assembled to the nose end of the body by means of pipe threads which seal the bomb against leakage of the filler. The two authorized chemical loadings for the bomb were HS and WP. A full length burster of tetryl was used with both fillers. The bomb was functioned by the Mk.XIV Fuze, using the Mk.IIB Instantaneous Primer Detonator.

In 1934, the requirement that the chemical bomb must withstand safe dropping was eliminated. After much experimentation on thin case bombs, fuzed and unfuzed, the 30-pound M46 Chemical Bomb was standardized in 1940. This bomb was cylindrical in shape and was made of sheet metal. It was a great improvement over the old 30-pound M1 Chemical Bomb carrying much more filler (75 percent as compared to 30 percent) and gave a much more efficient distribution of the chemical filler. It incorporated the M108 Nose Fuze with a full length charge of tetryl known as the Burster M3. It was loaded with HS and WP.

Recent Developments. A 100-pound thin case bomb was standardized after the development of the 30-pound M46. This was designated as the 100-pound M47 Chemical Bomb. It had a filler of WP or incendiary oil. It utilized the M108 Nose Fuze with the M4 Burster of tetryl.

The 30-pound M46 in the meantime had undergone changes in its fin assembly to make it more stable in flight and body construction. It was modified so that its latest designation was 30-pound M46A2. However, because of the change in Air Force tactics, the tactical use of this bomb became quite limited. Fighter planes no longer had racks to fit this type of bomb. Experimental clusters of six bombs required as much room as a 500-pound demolition bomb and were deemed a great waste of space. Consequently, in 1942, all the 30-pound M46 Bombs with their modifications were declared obsolete and the 280,000 of these bombs found in the field were withdrawn and returned to Chemical Warfare Service for use as components in chemical land mines.

Chemical Bomb Nose Fuze M108.

General. This is an arming pin type of fuze with instantaneous arming action and instantaneous action on impact. It is possible to use this type of fuze on chemical bombs because this would cause no damage to a plane, were they to function immediately upon clearing the bomb bay. This, of course, is not the case with H.E. bombs. The M108 Fuze is used on the 100-pound Chemical Bomb M47 or its modifications. The fuze is packed 1 per container, 200 per box.

Description. This fuze has an over-all length of 2.66 inches. A striker assembly protrudes approximately ¾ inch beyond the nose of the fuze body. At the rear of the body are two spring-actuated steel balls diametrically opposed, which engage in the groove of the burster well adapter when the fuze is inserted in the nose of the bomb. This operation, performed solely by hand and without the use of force or tools requires no screwing. An arming pin with two transverse eyelets and positioned on a compressed spring, extends through both fuze body and striker shaft, thereby preventing movement of the striker. Also extending through both fuze body and striker is a shear wire. Incorporated as an integral part of the fuze is a detonator assembly.

As an added safety device for this fuze, a steel spring-loaded safety block is mounted between the striker head and fuze body. It is retained in place by a safety-block holder which is a thin metal plate fitting under the arming wire in the arming pin. It bears against the safety block and holds it in place. Upon fuzing, the arming wire is threaded through the inner eyelet and the cotter pin is removed.

The original M108 Fuze did not have the safety-block assembly. When used with the 100-pound chemical bomb, it was found to be quite dangerous because a drop of about 6 inches on a hard surface was sufficient to function the fuze despite the safety features. M108 Fuzes in the field without safety-block assemblies should be modified by inserting properly sized wooden blocks between the striker and fuze body and taping them securely in place. These blocks are removed only when the bomb is placed in the bomb rack.

Function. The bomb is dropped and the arming wire is retained in the plane. The arming pin is ejected from the fuze by its spring. At the same time, the safety-block holder, being free, is ejected by the safety-block spring. The striker is now held away from the detonator by a shear wire.

On impact, the striker is forced inward, shearing the shear wire and bringing the firing pin into the detonator. The detonator consisting of priming mixture, lead azide, and tetryl detonates and sends a wave to the burster charge of tetryl or black powder in the burster casing.

Chemical Bomb, FUZE, Nose, M126.

General. This is an arming vane type of fuze with mechanical delay in arming. It has instantaneous action on impact which is in all

cases necessary to provide for dispersion of chemical filler before any penetration can occur. It is used in the 100-pound Bombs M47A1 and M47A2 when dropped in clusters, and also in the 115-pound M70 Bomb.

Description. This fuze is similar to the AN-M110A1 with the elimination of the booster housing and booster charge, and with the incorporation of a detonator housing instead of a cup for the detonator charge. In all other respects, it is similar to the AN-M110A1 described in the chapter dealing with fragmentation bombs. It was designed to prevent the bomb from functioning too close to the plane. Especially is there a possibility of this if the bombs are to be dropped in clusters.

Function. In function it is similar to the AN-M110A1. Upon impact, however, the firing pin functions a detonator. The function in so far as the fuze is concerned ends at this point. In the AN-M110A1 a booster of tetryl which is part of the fuze is detonated by the detonator.

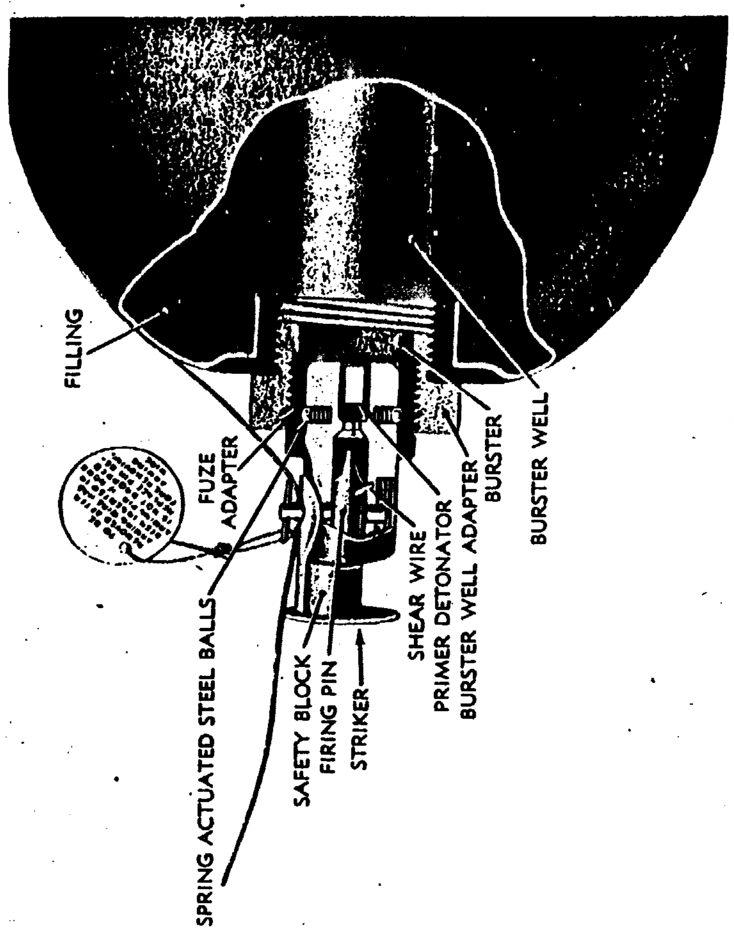
BOMB, CHEMICAL, 100-POUND, M47.

General. This bomb was developed to meet the requirements of the Air Forces for a chemical bomb for "bombardment" purposes. It is a thin case bomb whose design and construction is such as to provide maximum efficiency after release from the bomb bay of the plane.

Bomb Description. The body of this bomb is made of 1/32-inch sheet metal rolled and lap welded into a cylindrical shape 8 inches in diameter. The nose is hemispherical and welded to the body as is the box type tail fin assembly which forms the tail taper of the bomb body.

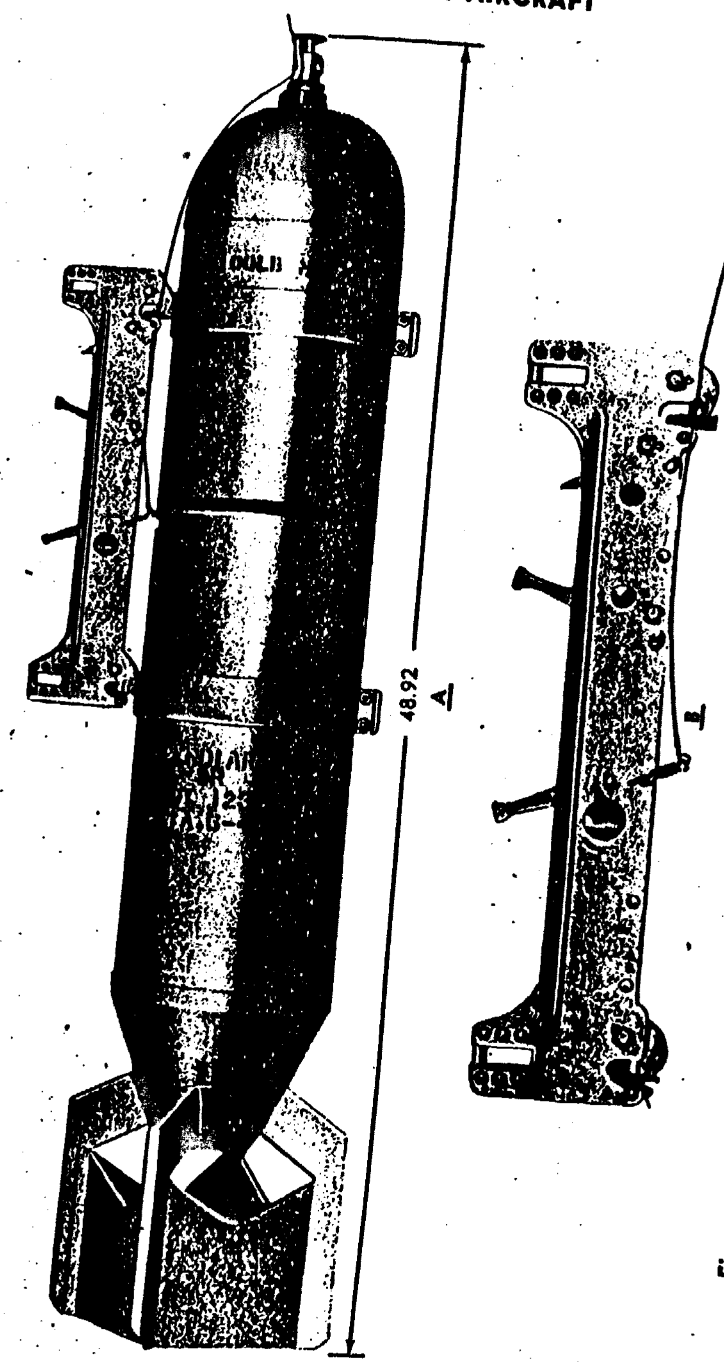
The over-all length is 45 inches excluding fuze, and the weight, after insertion of the burster well, is 20 pounds. The burster well is screwed into the bomb body by means of pipe threads to make a gastight seal at nose. It is held in place at the tail of the bomb body by an attached cone in the inner side of the fin assembly. It is internally threaded to receive a sleeve which has a groove in its lower portion to seat the fuze which is pressed in place. The pipe threads are coated with either white lead-in-oil, red lead-in-oil or varnish shellac before the burster is inserted to make a leaktight joint. The center of gravity is about 18.5 inches from the nose. Around the bomb body are two suspension bands 14 inches apart which provide suspension lugs for horizontal suspension. One blade of the fixed box type tail assembly is in line with the suspension lug.

It utilizes the Bomb Fuze M108 (Nose) in conjunction with the M4 Burster which has a charge of tetryl when used with a WP or



RA PD 15071

Figure 262 — Assembly of 100-pound Incendiary Bomb M47



RA PD 15070

Figure 263 — Bomb Release Mechanism and 100-pound Incendiary Bomb M47 Attached

H filler. The H filler has been found to leak when loaded into this bomb and the M47A1, and is not to be loaded into the M47 or M47A1 Bombs at the present time. When loaded with H, the entire weight of the bomb is 93 pounds of which 73 pounds is H.

The bomb may be loaded with an incendiary filler of rubber and gasoline in the field. The base filling is gasoline supplemented by one of four different incendiary ingredients as follows:

1. *LA-60.* Consists of crude latex or sap in combination with caustic soda, cocoanut oil, and water.

2. *Crepe rubber (CR).* This is crude latex but is reduced to a solid by precipitation and kneading.

3. *LA-100.* This is crude latex dried until it is approximately 100 percent solid.

4. *Smoked rubber sheets (SR).* This is crude latex which has been dried over a smoky fire until it is approximately 100 percent solid.

When loaded with the incendiary filler the Fuze Bomb M108 (Nose) with a 1-pound black powder Burster Charge M7 is used. This burster charge bursts the bomb and scatters and ignites the filler. When filled, the body weighs 85 pounds of which 65 pounds is incendiary filler. This is a typical example of the scatter type of incendiary filler.

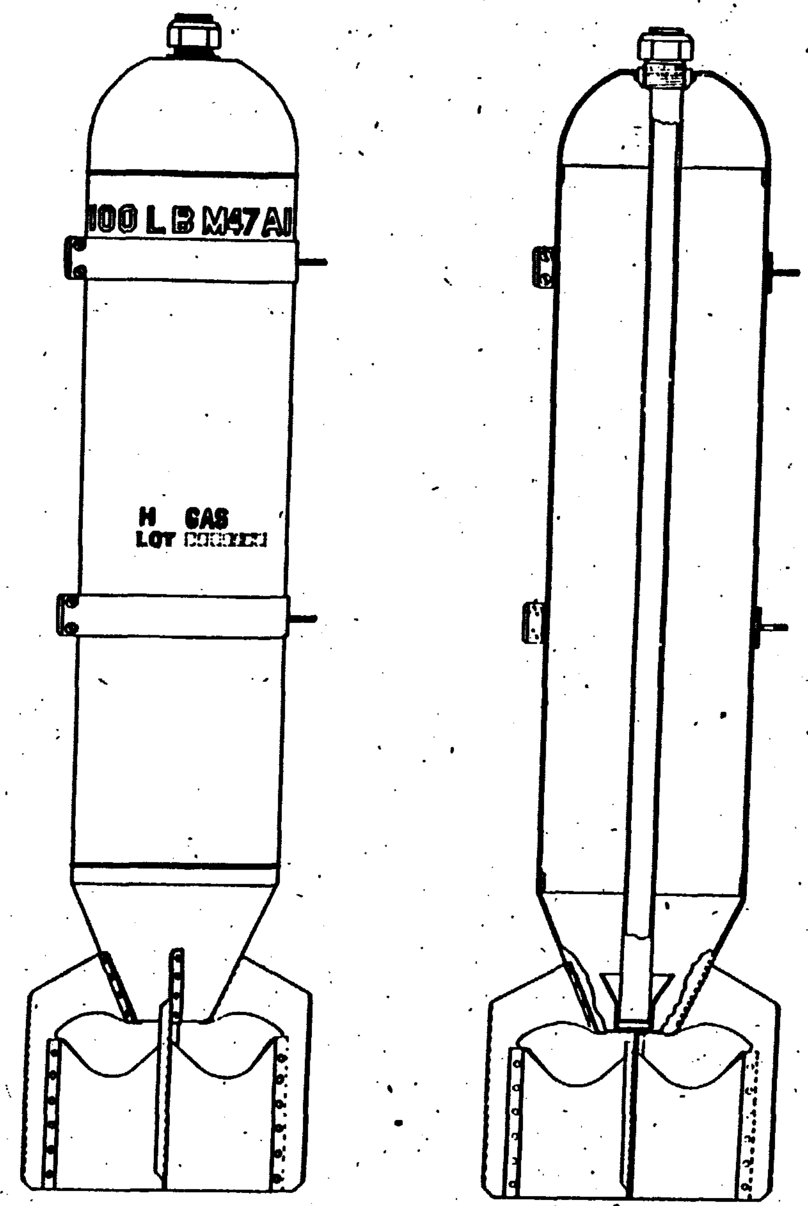
Painting. The bomb is painted as other chemical ammunition with a blue-gray base color. If loaded with H, it will have two green bands and will be stenciled in green. If loaded with WP, it will have one yellow band and will be stenciled in yellow. If loaded with incendiary filler, it will have one purple band and will be stenciled in purple. The stenciling for the incendiary bomb will indicate the type of rubber filling such as "incendiary oil, LA-60" or "incendiary oil SR."

Packing. This bomb is packed in a wooden box, one per box without fuze, arming wire or burster charge. Incendiary oils are loaded in the field into the empty bombs.

BOMB, CHEMICAL, 100-POUND, M47A1.

General. This bomb was designed to replace the 100-pound M47. The 100-pound M47 was found to have too thin a wall section, and in handling and storage, it developed leaks due to corrosion and rough treatment. Consequently, the wall thickness was increased from 1/32 inch to 1/16 inch, and the case was protected by coating inside with acidproof black.

Comparison. In design, it is similar to the 100-pound M47. It is, however, approximately 9 pounds heavier and weighs, when loaded with H, 102 pounds, of which 73 pounds is H. When loaded with



RA PD 23019

Figure 264 — Bomb, Chemical, 100-pound, M47A1

incendiary oil, it weighs 94 pounds, of which 65 pounds is incendiary oil.

In fillers, fuze, painting and packing, it is exactly the same as the 100-pound M47. It has a special inside coat of paint which provides a resistance of 100-pound pressure. However, H was still found to leak from the bomb case as with the previous bomb and is not to be loaded in empty 100-pound M47A1 Bomb Cases. The only standard fillers are WP or incendiary oils.

An additional fuze which may be found used with this chemical bomb is Fuze Bomb M126 (Nose).

BOMB, CHEMICAL, 100-POUND, M47A2.

General. This bomb was designed to be able to receive the chemical filler mustard (H) without leaking. It was coated on the inside with a special oil which proved in theoretical tests to be resistant to filler pressure having a resistance of 400-pound pressure.

Comparison. It does not differ from the 100-pound M47A1 in any appreciable way. It has the inside wall painted, however, with the special oil to make it resistant to H. It was found, however, that this bomb was also subject to leaking, but not to such an extent as its predecessors. H is still to be loaded into this bomb as a temporary emergency filler. Other fillers are WP and incendiary oils. The fuze is the Nose Bomb Fuze M108 or Fuze Bomb M126 (Nose). When the M126 Fuze is used, the special adapter for the M108 Fuze is removed, as the M126 Fuze can screw directly in the burster well. In all other components, the bomb is exactly the same.

BOMB, CHEMICAL, 115-POUND, M70.

General. This bomb was designed to receive a chemical filler of mustard (H) without any possibility of leaking. It is a thick case bomb as compared to the bombs which preceded it.

Comparison. In shape, construction, and weight, the bomb resembles the 100-pound general purpose bomb. It is somewhat longer, however. It is cylindrical, having a rounded nose and tapered tail. The body is constructed in one piece without any welds. At the base, however, a closed base plug which has a threaded protrusion is welded to the bomb body. The threaded protrusion receives a fin lock nut which seats the fin assembly snugly on the bomb. The nose of the bomb is unthreaded but receives a long burster which is press-fit into the nose to form a gastight seal.

Welded to the bomb body are three lugs. Two lugs 14 inches apart are provided for horizontal suspension, and a third lug on the opposite side at the center of gravity is provided for single suspension.

The burster casing receives a Burster Charge M10 and is threaded to receive Fuze Bomb M126 (Nose). The filler is at the present time H only.

FURTHER REFERENCES: A complete list of references may be found at the close of this section.

Chapter 7
Incendiary Bombs

GENERAL.

Definition. Incendiaries are combustible materials which are burned with intent to cause destruction of buildings, crops, food, ammunition, or materials of military importance.

Incendiaries dependent on their construction and manner of use are classified as intensive or scatter. The intensive type remains as a unit until consumed, thus confining its heat to a restricted area. The scatter type dispenses small fragments of its burning material usually by an explosive charge, thus starting simultaneously as many fires in as many different places as possible. Examples of the scatter type are the 100-pound gasoline rubber filled bomb and the 6-pound oil incendiary filled bomb. Some of the chemical bombs discussed in the preceding chapter are called a scatter type incendiary if the filler is of an incendiary nature. The M47 series of chemical bombs are an example.

Theory. For every incendiary bomb dropped, a fire is not started. The practice is to scatter the bombs over the heart of an entire city. The average city has 85 percent of its area devoted to parks, roads, valleys, back yards, and front yards, leaving 15 percent of the average city composed of some incendiary composition.

If a bomber carrying 2,000 of the small 2-pound incendiaries were to travel at a speed of 200 miles per hour dropping 20 bombs per second, the plane would travel 6 miles before it expended its cargo of incendiaries. Of 2,000 dropped, only 300 bombs will strike possible targets. One half of these will harmlessly ricochet off roofs or fail to find combustible roofs.

Thus it is obvious that for every 2,000 bombs dropped over the modern city, only 150 bombs will ignite targets; thus, only 7½ percent of those dropped will be effective.

Chemical Bomb, FUZE, Transverse, M1.

General. This fuze is used in the 6-pound Oil Incendiary AN-M69 and in the 10-pound WP incendiary AN-M67. It is threaded at one end so as to seat itself in threads located in the side of the bomb body near its nose portion.

Description. This fuze contains a safety plunger which is positioned on a spring so as to be partially ejected from the fuze housing when it is free or in the armed position. The ends of the safety plunger protrude from the fuze housing at the point where the threads are located. Passing through the fuze housing is a striker in the form of an E. The upper portion of the E-shaped striker is held in place by the end of the safety plunger in the unarmed position. The middle portion of the E-shaped striker is in the form of a firing pin and is directly over a primer. The lower portion of the E-shaped striker is resting against a spring which prevents the striker from moving down on the primer in the armed position before impact occurs.

Underneath the primer is a black powder spitter fuze which leads to a black powder booster charge located at the end of the fuze opposite the threads. The fuze should be inserted in the side of the bomb with the arrows which are located on the external surface of the fuze body pointing to the rear.

Function. The cluster is dropped and the arming wire is retained in the plane. The cluster opens and the bombs fall free. The safety plunger which had been imprisoned by intimate contact with the bomb next to it, is now free and is partially ejected by its spring from the fuze housing. The striker is now free but is restrained from striking the primer by a restraining spring.

On impact, the force of inertia causes the striker to move against its spring bringing the firing pin into the primer. The flame from the primer ignites a black powder spitter fuze which in turn sets off a black powder booster charge. The booster charge functions a charge of black powder and magnesium mixture which ruptures the bomb case, spreads the filler, and ignites it.

BOMB, INCENDIARY, OIL, 6-POUND, AN-M56.

General. This bomb is a relatively new bomb designed to be dropped from clusters to produce an incendiary effect. It is of the scatter type and is filled with an incendiary oil, the composition of which at the present time is unknown.

Bomb Description. The incendiary bomb is contained within a hexagonal light steel case 19.5 inches long and 2.9 inches wide. This outer case is divided into three compartments. The tail compartment contains 9.5 feet of 3-inch gauze which occupies 1.5 inches. In the main body of the bomb is loaded the oil emulsion filler. The **FUZE,** bomb, M1, occupies about 1.5 inches in the nose end and is separated from the filler by an impact diaphragm. The fuze should be inserted

in the side of the bomb with the arrows pointing to the rear. The bomb is designed to be packed in clusters.

Function. Upon release from the plane, the cluster breaks apart and the safety plunger of each bomb which was imprisoned by intimate contact with the bomb next to it, is free to move partially out under spring action. This arms the fuze. At the same time, the gauze streamer is forced out by air pressure and serves to stabilize the bomb in flight.

Upon impact, the striker moves down against its spring and strikes the primer. The flame ignites the spitter fuse which functions a black powder and magnesium mixture. The combined action of these charges ruptures the impact diaphragm and ignites the oil filler. The mixture is spread over an area of 100 yards. The oil emulsion which is known as IM or NP burns at a temperature of 700 C.

BOMB, INCENDIARY, WP, 10-POUND, AN-M67.

This bomb is identical to the AN-M69 described above in description and operation, but the filler is white phosphorus rather than incendiary oil.

BOMB, INCENDIARY, 4-POUND, AN-M50A1.

General. This magnesium type of incendiary bomb is patterned after the original German "Elektron" bomb but incorporates several distinct improvements including a blunt steel nose and a bigger stabilizing fin assembly. It is of the intensive type.

Description. This bomb measures 21.69 inches in length and 1.69 inches in width at the hexagonal cross section, with the center of gravity located 6.5 inches from the tip of the nose. The bomb consists essentially of a hexagonal blunt steel nose, a cored magnesium alloy body containing a first fire charge, and a thermate igniting composition, a striker unit with a safety plunger, and a hollow, hexagonal sheet steel tail approximately 8 inches long. The total weight of the AN-M50A1 Bomb is approximately 4 pounds, apportioned approximately as follows:

Magnesium alloy	1 lb 4 oz
Steel nose	1 lb 8 oz
Thermate igniting mixture	10 oz

The firing mechanism and tail assembly make up the balance of the weight.

Description. The striker is held away from a primer by the safety plunger which is actuated by a spring tending to eject the plunger partially out of the bomb body. It is prevented from doing so by being imprisoned in intimate contact with the bomb adjacent to it. In the armed position, the striker is held off the primer by a thin brass cross which rests on a firing pin holder.

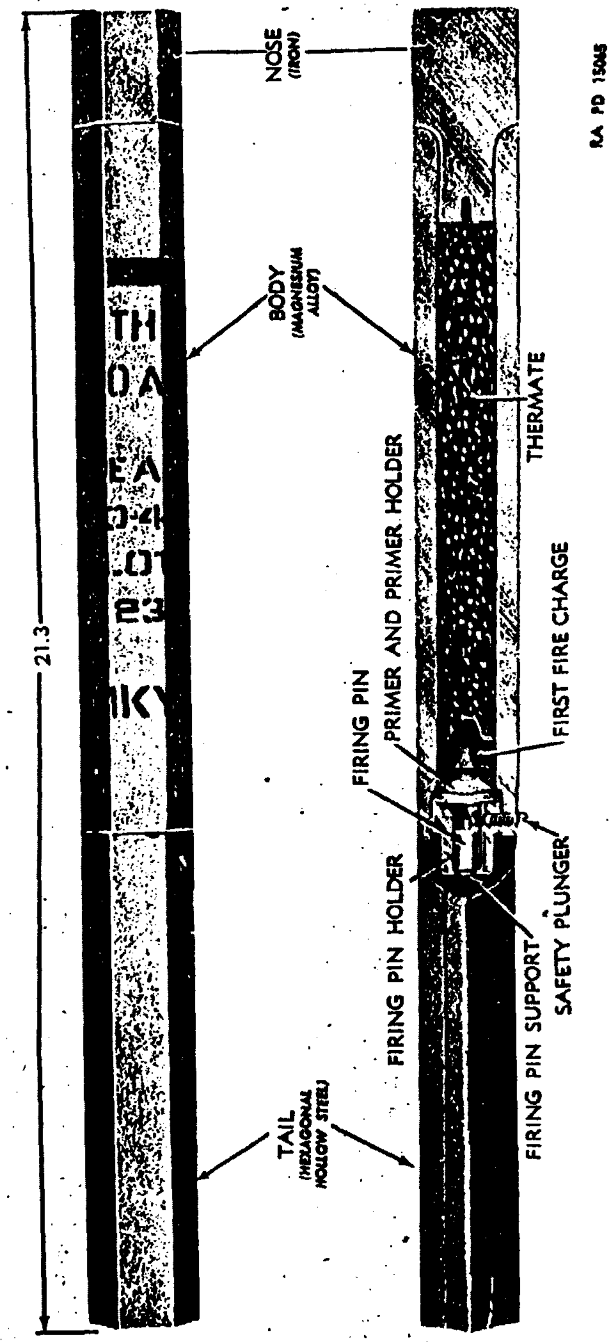


Figure 265 — BOMB, Incendiary, 4-pound, AN-M50A1

The design of the bomb is such as to set in motion the first of its functions immediately upon impact when released from a height of 50 feet or more above a target. Greater heights of release are always used, however, so that a maximum velocity consistent with a predetermined accuracy may be obtained, thus assuring to the bomb a maximum penetration upon impact.

Function. The cluster is dropped and the arming wire is retained in the plane. The cluster opens and the bombs fall free. The safety pin or plunger is now free and is partially ejected by its spring from the body of the bomb. The striker is now held in position by only the brass T-cross. The bomb is now armed. The hollow tail assembly and the heavy steel nose plug assure a vertical flight of the bomb in the air.

Upon impact, the force of inertia exerted upon the striker is sufficient to send it downward through the firing pin holder, pulling after it the thin brass cross. The consequent impact of the firing pin on the primer ignites the first fire charge. The fire charge ignites the thermate mixture and this ignites the magnesium alloy body. For a period of about 10 minutes, the body burns at an intense heat of 2,300 F to 2,500 F.

Painting and Stenciling. The bomb is painted a blue-gray base color with one purple band and purple stencil to indicate a nonpersistent incendiary. The lettering is in panel form surmounted by the band on the body of the bomb and gives the following information in two size letters as follows:

Purple band	——
Thermate	TH
Model number	AN-M50A1
Loader's initials or symbol	EA
Date of filling	10-41
Loader's lot number	Lot 123

Packing. These bombs are packed 34 to a cluster in a metal-lined wooden box. Larger cluster may be found having 62 and 128 bombs to the cluster.

BOMB, INCENDIARY, 4-POUND, AN-M50XA1.

This bomb is approximately equal in weight and is identical in measurement to the AN-M50A1 described above, and differs only in composition in that it contains a burster charge of 170 grains of black powder. The black powder burster charge is contained in a metal case near the nose of the bomb. The presence of the burster charge decreases the weight of the thermate igniting mixture by a slight amount.

The burster charge is incorporated to make hazardous an immediate approach to a burning bomb, thus discouraging attempts at extinguishing all 4-pound incendiaries. In this way, it increases the life span and burning efficiency of the standard Nonexplosive Incendiary AN-M50A1. The burster charged bomb may be said to "run interference" for the nonexplosive bomb. It explodes about 1½ minutes after the bomb is functioned. Approximately 20 percent of 4-pound magnesium alloy bombs in a cluster are of the AN-M50XA1 type.

BOMB, INCENDIARY, 2-POUND, AN-M52.

This bomb is similar to the AN-M50A1. It is shorter, 14.25 inches long, although it is the same width. It has no steel nose, nor does it have a long hollow tail assembly, although it has a short sheet metal tail approximately 5 inches long. In all other respects, except for the weight of the components, it is the same as the AN-M50A1. It is of the intensive type. The firing mechanism, the first fire charge, the thermate igniting composition, and the hexagonal magnesium case is the same. It is designed to be loaded so that 51 bombs may fit into 100-pound adapter clusters, 93 bombs into 250-pound adapter clusters and 192 bombs into 500-pound clusters. Upon function, the bomb burns at an approximate temperature of 2,400 F for a period of approximately 6 minutes.

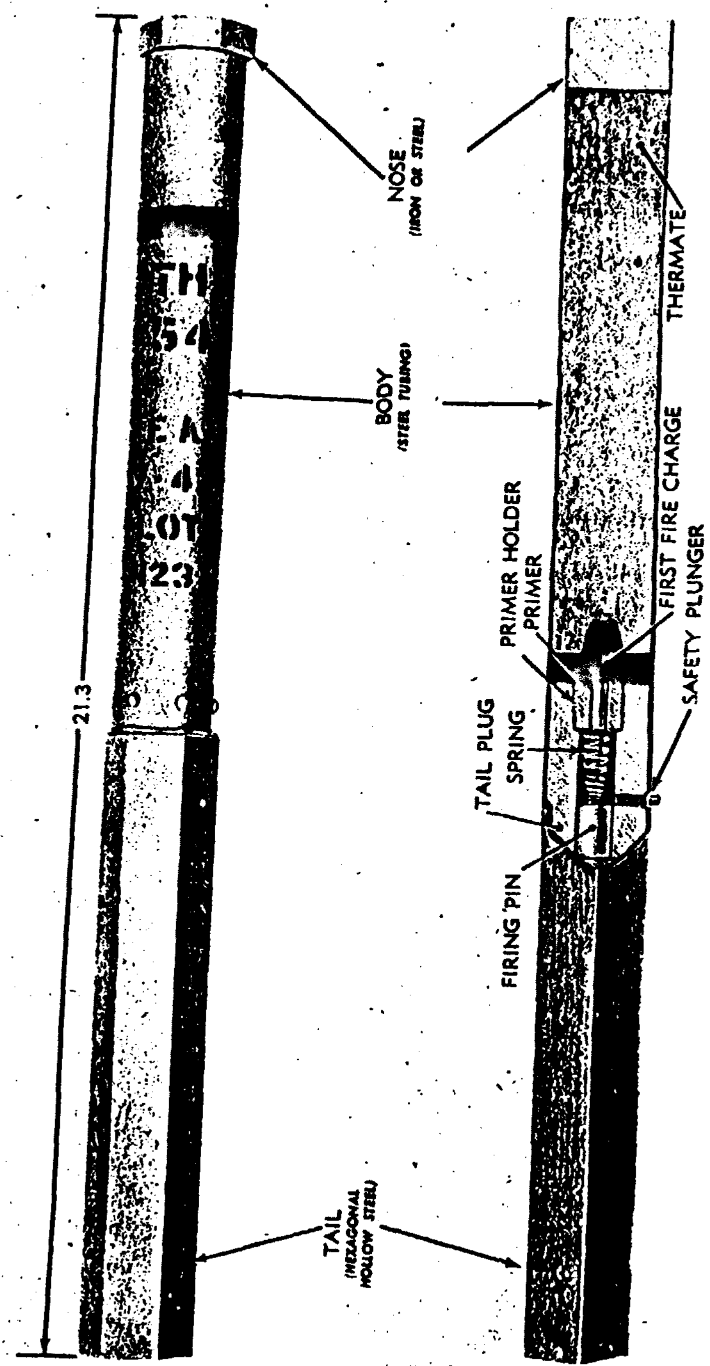
BOMB, INCENDIARY, 4-POUND, AN-M54.

General. This bomb is similar to the 4-pound AN-M50A1 but it is designed to be used against much more resistant targets such as inflammables encased in metal as oil tanks. It burns at a much higher temperature and for a much shorter period of time. It is of the intensive type.

Description. Although within a fraction of an ounce of the same weight and of almost identical appearance, the AN-M54 differs considerably from the AN-M50A1 in its construction. The major difference is in its body, which is of tubular steel, and in the amount of thermate igniting mixtures. This allows for a much higher burning temperature although a much shorter time of burning.

There are also other differences in the weight and shape of the steel nose, in the design and operation of the firing mechanism, and in the weight and design of the tail. The striker, instead of being checked by a thin brass cross, is restrained by a 1¼-inch thin, wire spring attached to its nose. The spring has a pressure resistance equal to 25 ounces in weight.

The lengths of the two bombs are almost identical, and the diameter of the hexagonal noses and tails is almost the same. The center of gravity of this steel body bomb, however, is 6 inches from the tip of the nose, or ½ inch nearer the nose than in the magnesium type. Similar to the 4-pound magnesium bomb, the weight of this incendi-



RA PD 15067

Figure 266 — BOMB, Incendiary, 4-pound, AN-M54

ary is approximately 4 pounds apportioned approximately as follows:

Steel body	1 lb 6 oz
Steel nose	10 oz
Thermate igniting mixture	1 lb 10 oz

The balance of the weight is distributed in the tail assembly and firing mechanism.

Function. The cluster is dropped and the arming wire is retained in the plane. The cluster opens and the bombs fall free. The safety pin or plunger is now free and is partially ejected by its spring from the body of the bomb. The striker is held in position by a restraining spring. The bomb is armed. The hollow tail assembly and the heavy steel nose plug assure a vertical flight of the bomb in the air.

Upon impact, the force of inertia exerted on the striker is sufficient to send it down against its spring. The firing pin functions the primer charge which ignites the first fire charge. The first fire charge ignites the thermate igniting mixture in the bomb core. For approximately 1 minute, the thermate burns fiercely at a temperature between 4,300 F and 4,400 F. This intense heat melts the tubular steel body, releasing molten metal to run in many directions, searing and igniting combustible material with which it may come into contact.

Marking and Packing. The marking and packing for this bomb is exactly the same as that described for the AN-M50A1, except for the fact that where the number 50 appears in the nomenclature the number 54 will replace it.

BOMB, INCENDIARY, 4-POUND, AN-M54X.

This bomb is identical to the AN-M54 described above except for the fact that a burster charge of 170 grains of black powder is incorporated in the core near the nose. This is similar to that in the AN-M50XA1. The purpose of the burster charge is the same as that previously described with the Bomb AN-M50XA1. The M54X Bombs are packed in clusters with the M54, the M54X making up about 20 percent of each cluster.

BOMBS, INCENDIARY, INSTRUCTIONAL, GENERAL.

Instructional incendiaries have no relation to aircraft and should not be confused with the incendiary bombs previously discussed. Their design, construction, ignition, and purpose differ from the standard types. Only in the materials of their composition and in the nature of their final function do they approximate incendiary bombs in the true sense of that term.

Purpose. Instructional incendiary bombs are designed for the purpose of demonstrating to troops and qualified civilians the functional time element and incendiary action of certain types of incen-

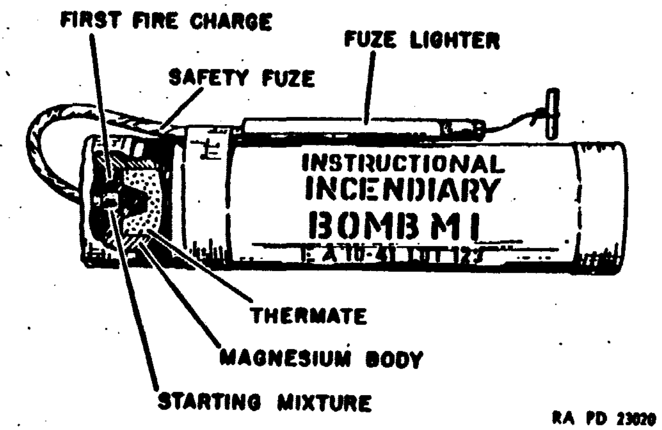


Figure 267 — Instructional Incendiary Bomb M1

diaries. When burning, they and the materials ignited by them provide opportunities for instruction in methods of control of burning magnesium and thermate bombs and the extinction of fires initiated by them.

Use. Since they are employed for training and educational purposes, instructional incendiary bombs are used at military and naval training centers and before civilian protective groups and agencies. Rather than being released from aircraft, dropped from stationary heights, propelled by mechanisms or discharged from weapons, they are hand-ignited and positioned by hand upon or near the material to be set afire. Their control is thus completely vested at all times in the hands of the instructor or demonstrator. For this reason, they may not properly be termed "practice" bombs as such classification is sometimes accorded to various other types of aircraft instructional bombs.

BOMB, INCENDIARY, INSTRUCTIONAL, M1.

General. This bomb simulates the magnesium type of incendiary bomb and is designed to give instructional methods in the handling of bombs whose basic composition is the magnesium body.

Description. This bomb, 2 inches in diameter and 9 inches in length, is cylindrical in appearance and is constructed of an extruded length of magnesium alloy tubing. One end is closed by a tin cap held in place by an 8-inch length of waterproof adhesive tape ¾ inch wide. The 1-inch diameter core is packed with the thermate igniting mixture to within ⅝ inch of its fuzing head. This remaining space is filled with the first fire charge to within ¼ inch of the end of the bomb, at which point a metal closing disc is inserted and secured by a second 8-inch strip of waterproof adhesive tape. All fillings are subjected to a pressure of 5,500 pounds per square inch.

Three holes perforate the closing disc, one in the center, and two ⅜ inch off the center. An 8-inch length of safety fuse, one end of which has been treated with a mixture of collodion and black powder and rests within a depression of the first fire charge, passes through the center hole, carries up and back and is taped to the bomb. After the installation of the fuse, the rim of the center hole is sealed with cement and coated with quick drying shellac. The off-center holes of ¼-inch diameter, serving as gas vents are covered with ¾-inch squares of waterproof adhesive tape and coated with varnish shellac. A pull wire fuse lighter is taped to the bomb but not assembled to the fuse.

Ignition. After ¼ inch has been cut cleanly from its end, the fuse is inserted in the fuse lighter with moderate pressure. The bomb is then held firmly in one hand with the thumb pressing the fuse lighter flat against the bomb body. With the other hand, the handle of the fuse lighter is pulled sharply away from the fuse which will burn for 30 seconds before igniting the first fire charge. The bomb will then burn for 5 minutes.

Safety Precautions. The following safety precautions should be observed when igniting instructional incendiary bombs:

Protect the hand holding the bomb with a heat-resisting glove or pad.

Point the fuze end of the bomb away from the face and body when pulling the fuze lighter.

Place the bomb in its predetermined incendiary position immediately after pulling the fuze lighter.

Stand at least 10 feet from the bomb after it has been placed in its incendiary position.

Remain in such position for at least 30 seconds after the bomb has ignited.

Marking and Packing. The instructional incendiary is marked with one band and lettering in purple lacquer enamel to indicate its type, the initial or symbol and lot number of the loader, and the date of filling.

Bombs are packed in cartons designed to contain four bombs each, and thence packed in wooden boxes designed to contain from six to eight such cartons. Packing cartons and shipping boxes are both marked in the same manner as the bomb body.

BOMB, INCENDIARY, INSTRUCTIONAL, M2.

General. This bomb simulates the thermate type of incendiary bomb and is designed to give instructional methods in the handling

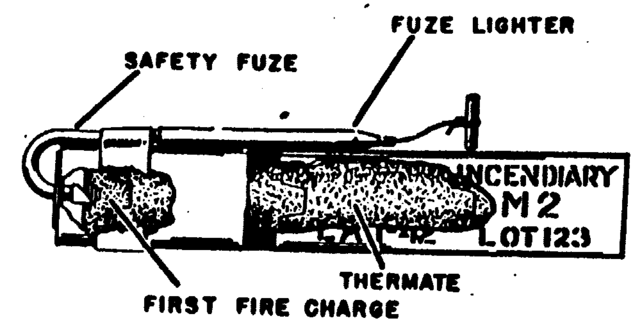


Figure 268 — Instructional Incendiary Bomb M2

of bombs whose basic composition is the thermate igniting mixture and steel body.

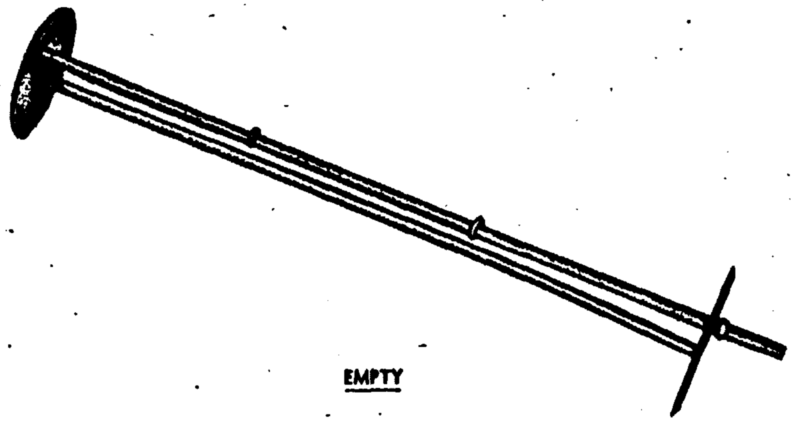
Description. Only in structional substances and in minor details does this thermate bomb differ especially from the foregoing magnesium type. It is 9 inches in length, but its body has a diameter of only 1½ inches and is constituted of steel tubing 0.04 inch thick. One end is closed by a tin plate, friction fitted and soldered, the other by a similarly soldered plate containing a center fuze hole and three vent holes equally spaced around the center. The body filling consists of thermate capped by a first fire charge. A 6-inch powder time-train fuse tipped with a collodion and black powder mixture is assembled in the same manner as in the M1 Bomb. The vent holes are taped; both they and the run of the fuze holes are treated with commercial liquid solder to insure waterproofing. A pull wire fuse lighter is taped to the bomb but not assembled to the fuse.

Ignition. This bomb is ignited in the same manner as the M1 previously described. The burning time for this bomb is 75 seconds, however.

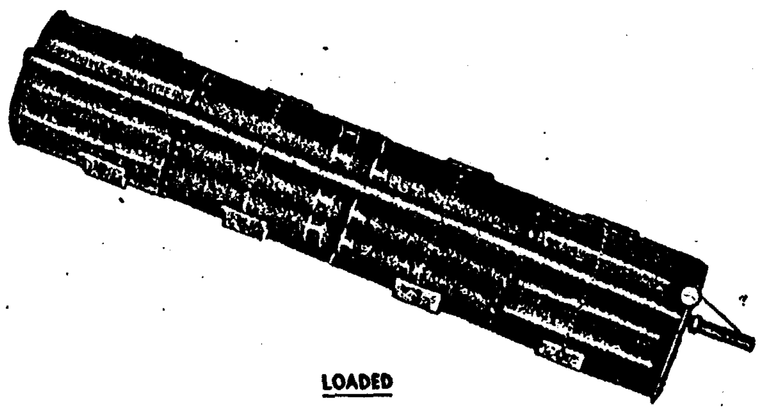
Safety Precautions, Marking and Packing. The safety precautions, marking and packing described for the M1 Instructional Incendiary Bomb apply in the same manner to the M2 Instructional Incendiary Bomb.

CLUSTER ADAPTER T2.

General. All intensive incendiary bombs (except instructional) are designed to be released from clusters. The use of adapter clusters permits the bombs to be dropped effectively over a given area and also permits the use of the same bomb racks for demolition bombs. The Cluster Adapter T2 is described as a 100-pound adapter and is designed to be suspended in bomb racks which receive 100-pound



EMPTY



LOADED

RA PD 23022

Figure 269 — Cluster Adapter T2 (Cartridge Type)

demolition bombs. It resembles the M1 Adapter Cluster used for fragmentation bombs.

Description. This adapter is composed of two thin steel end plates attached at right angles to two steel rods. The end plates are approximately 9 inches in diameter resembling a rounded shield or fat letter "U" closed at the top. One of the rods is 7/16-inch in diameter and is solid (separator), while the other is hollow with a 3/4-inch outside diameter (barrel). The hollow rod, open at one end, is attached to the top centers of the end plates; the solid rod is attached to the bottom. A series of four small transverse holes in the hollow rod are at equal distances between the ends. At about one third the distance from each end is welded a steel suspension lug.

Long wires pass through the four series of holes in the hollow rod or barrel. These encircle a total of 34 bombs separated into two equal lots, and each bomb is positioned so that its safety pin or plunger is imprisoned against the adjacent bomb. A cluster adapter metal support plate of three angled sides, each side of which is the equivalent width of one of the hexagonal sides of the bomb nose and tail, is on each side of the cluster in such manner, that the adapter plate grips the sides of three bombs. There are four such plates for a full adapter load each plate being notched at its top and bottom. The wire through the barrel passes through the notches of the cluster plates and the ends are twisted together under the solid rod, thus insuring two fast, compact, and immobile clusters of 17 bombs each within the adapter.

Assembly. A special ball type cartridge similar to that used in fragmentation bomb clusters described previously is inserted into the open end of the hollow rod and the assembled firing mechanism is screwed on the barrel. The completed and loaded cluster adapter is then attached to the bomb shackle by means of the two suspension lugs welded around and to the hollow rod, and the arming wire is substituted for the safety pin in the firing mechanism. The plane is now serviced for incendiary flight.

Function. The cluster is dropped and the arming wire is retained in the plane. The compressed spring forces the firing pin into the primer of the cartridge. The propelling charge is ignited and propels the bullet through the barrel, cutting the four wires holding the two clusters to the adapter. The bombs tumble out. The bullet spends itself against the plug in the sealed end of the hollow rod. In a few seconds, the bombs right themselves and speed earthward nose first, the slip stream of the airplane and the backwash of the propeller having dispersed them. The cluster must open before the bomb can be armed, and the bombs must be dispersed for proper incendiary effect. In all operations, the adapter falls as a unit to the earth, empty or filled, as the case may be.

Should it be necessary or desirable to rid the plane of its loaded cluster adapter unarmed, the arming wire is dropped with the incendiary cluster. This allows the cluster adapter with all of its bombs to fall as an intact unit.

Cluster Adapter Markings. It should be noted that the 4-pound incendiary bombs are not only manufactured as complete units in munitions plants, but are grouped in clusters as well, each cluster being "spotted" with its approximate 20 percent ratio of explosive or "X" bombs, and the finished cluster being properly loaded into the cluster adapter and secured as described.

The complete cluster is then packed in its metal-lined shipping box together with the arming wire. For this reason, it is necessary that proper information be shown upon each cluster adapter. Depending on the type of bomb, the following facts are stenciled in black upon the outside of one of the adapter end plates:

CLUSTER ADAPTER 100 LB. T2
FOR
34 INCENDIARY BOMBS
4 LB. AN-M50A1

CLUSTER ADAPTER AN-M3.

General. This cluster is designed to replace the Cluster Adapter T2. It is of the mechanical releasing type similar to the AN-M1A1 Adapter Cluster for fragmentation bombs.

Description. This cluster adapter is fundamentally similar to Cluster Adapter T2 described above, but is of noticeably different design and appearance. In place of the two parallel rods in the T2 Adapter, two parallel channelized bars of approximately $\frac{1}{16}$-inch sheet steel and 47.87 inches in length have been substituted. In addition, four $\frac{3}{4}$-inch thin sheet steel bands are substituted for the four cluster circumscribing wires, and three manipulative suspension lugs are set in a special affixed plate atop the upper bar to supersede the two welded lugs of the T2 Adapter in the same manner as the AN-M1A1 Cluster for fragmentation bombs.

The cartridge, and the four side support angle plates are not present. Four steel bands circumscribe the clusters, with band ends meeting above the top bar of the adapter, thus holding the bombs within the adapter frame. Each such function of ends is made fast by a common adapter length locking pin, which is assembled to the cluster adapter at the point of bomb manufacture. In the case of this cluster adapter, a 4-pronged arming wire is likewise assembled to the adapter at the point of bomb manufacture. The full adapter is attached to the bomb shackle by means of its suspension lugs. The last operation is the withdrawal of the common locking pin.

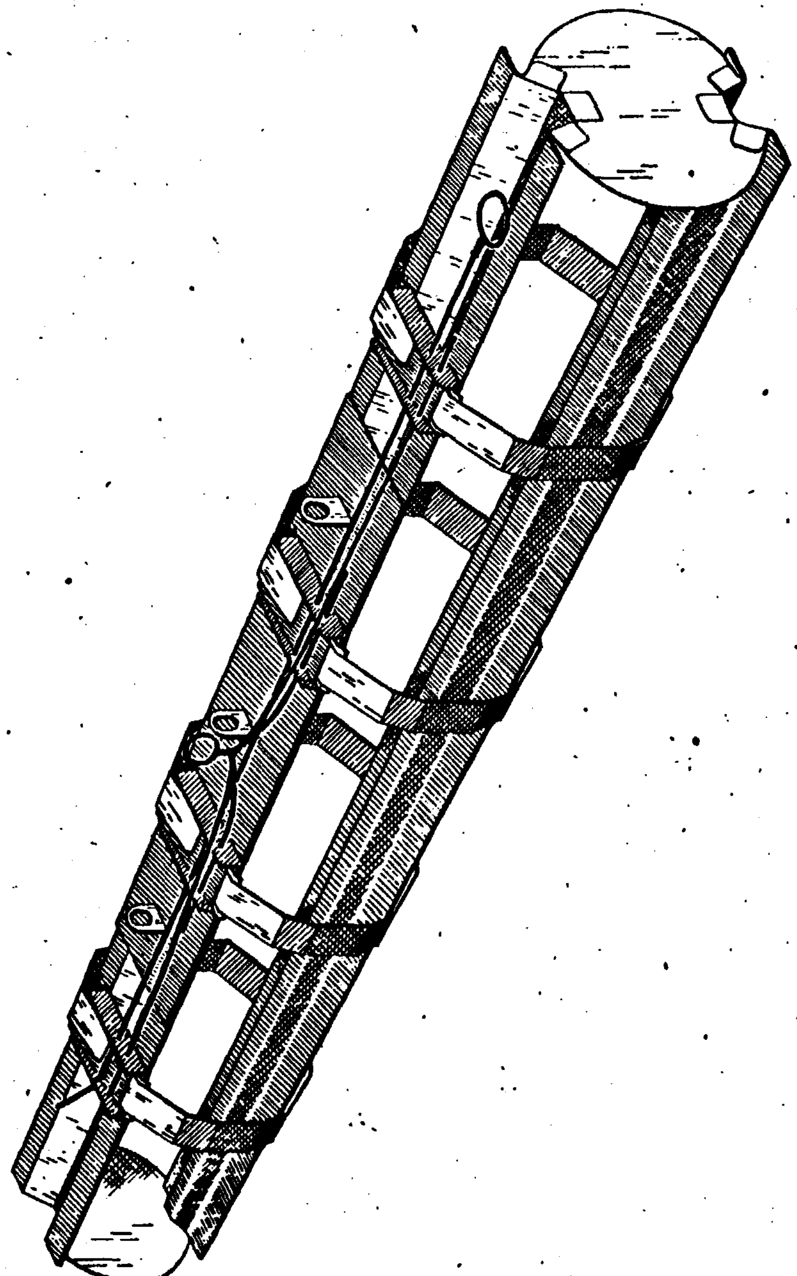


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Figure 270 — ADAPTER, Cluster, 100-pound (Incendiary Bombs), M3

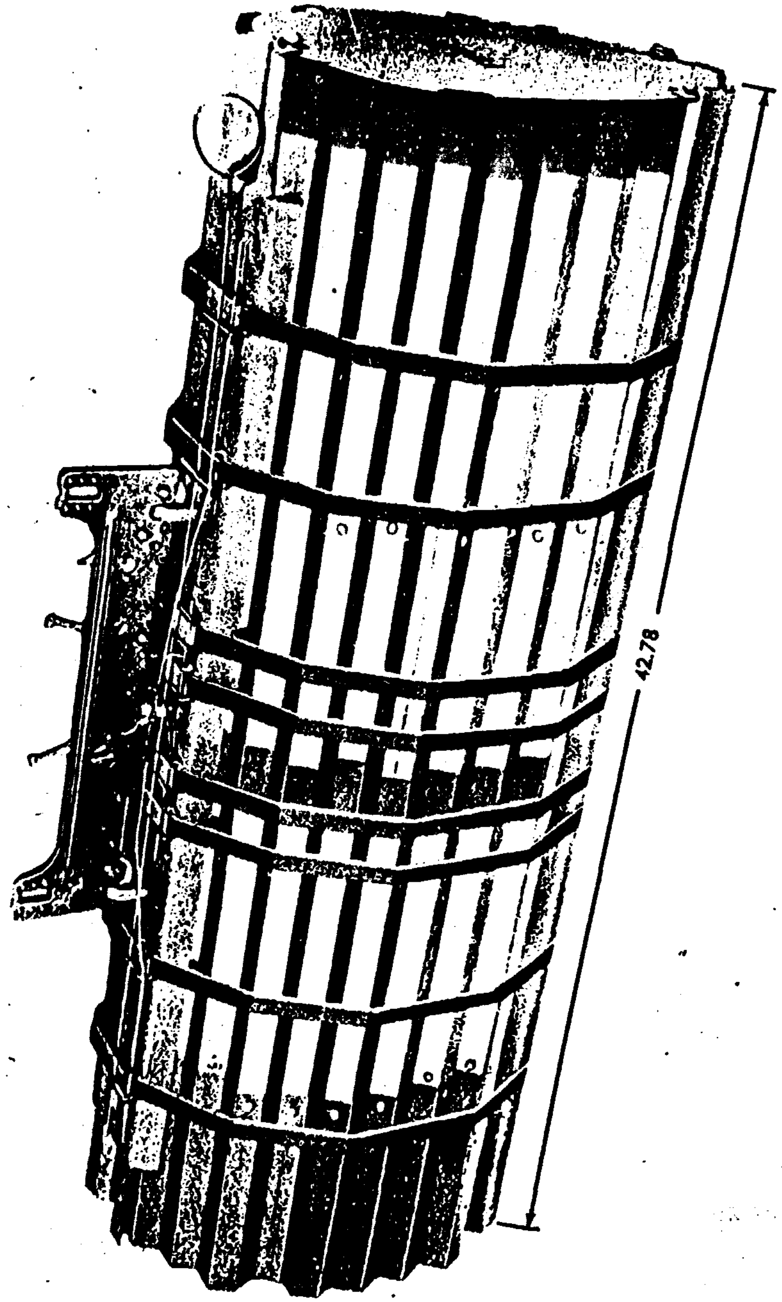

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Figure 271 — ADAPTER, Cluster, 100-pound (Incendiary Bombs), AN-M3

Function. The cluster is dropped and the arming wire is retained in the plane. The four prongs of arming wire release the steel bands which spring open and release the bombs. In a few seconds, the bombs right themselves and speed earthward, nose first, the slip stream of the plane and the backwash of the propeller having dispersed them. The bombs are now said to be armed. In this cluster adapter, the rods and end plates likewise fall apart and drop earthward.

Cluster Adapter Markings. In addition to the information described as stenciled upon one of the end plates of Cluster Adapter T2, the opposite end plate of Cluster Adapter AN-M3 will also bear the word "FRONT" for instruction in loading.

EXTINCTION OF AND CARE IN HANDLING INCENDIARY BOMBS.

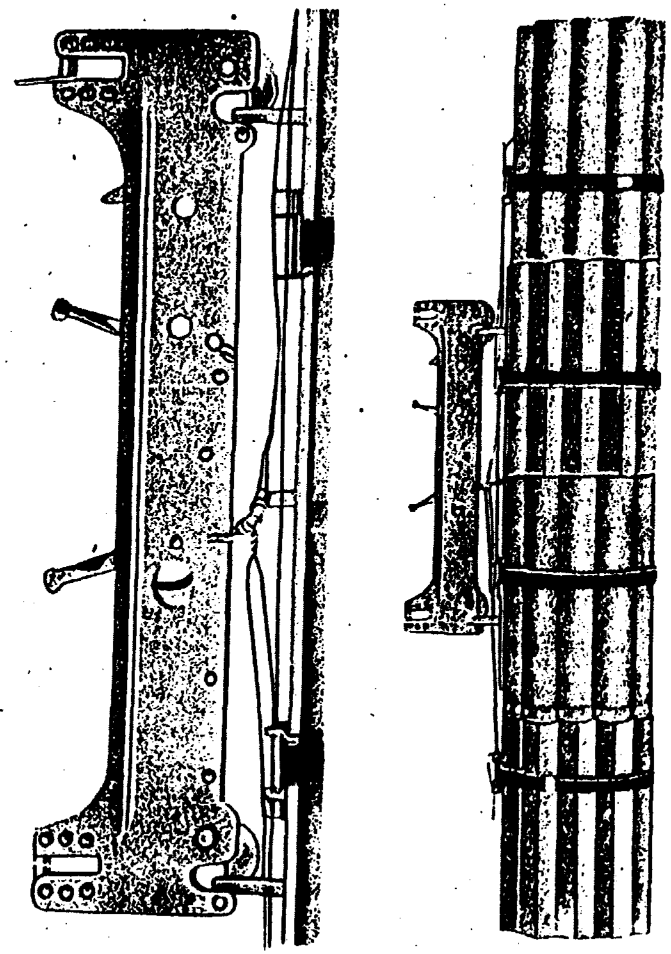
General. Incendiary bombs should be handled carefully. However, should one of the incendiaries described function when undesired, care, knowledge, and preparation is required to extinguish the bomb. It should be noted that the subsequent discussion applies only to the incendiaries discussed. Procedures to extinguish foreign incendiaries have recently changed to combat the new types found. These newer procedures are in sharp contrast to the procedure to be treated herein which is effective only for the incendiaries described previously.

In dealing with these incendiaries, efforts are aimed at control rather than extinguishment. Methods of control are described below, but in all instances one fundamental rule of conduct should be observed: Do not approach the bomb after its ignition until the expiration of 2 minutes. Both the spattering effect of the thermate igniting mixture and the burster charge explosion of the explosive bomb types are dangerous to personnel.

Control of AN-M50A1, AN-M50XA1, and AN-M52.

Water. In the use of water for control, care must be taken that no large amount such as a solid stream or a bucketful comes quickly into contact with the burning bomb. Should such occur, the resulting explosion will scatter burning fragments of magnesium over a considerable area. A fine water spray applied to the bomb will accelerate its burning rate and thus decrease the burning time.

Solids. Almost any powdered solid that is not of itself combustible is, to varying degrees, effective in controlling a burning magnesium bomb. Such substances, when thrown upon the bomb, decreases the amount of oxygen, thus causing the bomb to burn less violently. It may then be approached more closely and, if possible, moved to a less vulnerable place. This removal should be effected by means of a long-handled shovel, or some similar implement, and the bomb



RA PD 23023

Figure 272 — Bomb Release Assembly and Loaded Cluster Adapter M3, Attached

should be deposited in some receptacle, the bottom of which is lined with some noncombustible solid, preferably of a powdery nature. This fire resistant false bottom is more important, for without it the bomb might quickly burn through the vessel. Suggested solids include *sand, commercial fire resistant powders, talc, ashes, and earth.*

Chemicals. Chemical fire extinguishers are no more effective than water, and should be used with caution because of possible harmful physiological effects resulting from the reaction of burning magnesium and ingredients of certain extinguishers. Carbon tetrachloride, the filling of one type of extinguisher, gives off a vapor with anaesthetic properties similar to chloroform and is, therefore, dangerous in confined spaces. Accompanying this vapor may also be the toxic gas phosgene. Carbon dioxide, in contact with burning magnesium is broken down into carbon and deadly monoxide gas.

Control of AN-M54 and AN-M54X. These thermate and steel bombs burn at temperatures between 4,300 F and 4,400 F and cannot be smothered by water, sand, or other materials. This is true because the thermate mixture contains its own adequate supply of oxygen. The bomb simply must burn itself out, which it will do in not more than 2 minutes. Personnel should take pains to dispose of the molten iron produced during the thermate reaction.

Treatment of Burns From Incendiary Bombs. Particles of burning metal in contact with the skin should be removed at once. Should injury result from imbedded particles of magnesium bomb, relief may be obtained by application of petroleum jelly or some equivalent substance. But in no case should water be applied, as this will stimulate the burning rate of magnesium. For injury due to the thermate and steel bombs, flooding the affected surface with water will cool the molten iron and afford relief. Further treatment, once the metal has ceased burning, will be the same as that for any burn of like degree. Injury to eyes will require immediate medical or hospital treatment.

Care and Preservation. Extreme care should be exercised to insure that these bombs are stored in a dry place well removed from heat and fire. Rough handling is prohibited. If the airtight seal of the shipping containers is broken, the first fire charge of the bomb will absorb moisture which will radically interfere with ignition of the bomb. This is especially true of moisture-laden bombs loaded into a plane and carried aloft. The extreme low temperature of high altitude causes the first fire charge to freeze, thereby rendering the bombs completely useless for incendiary purposes.

FURTHER REFERENCES: A complete list of references dealing with bombs can be found at the close of this section.

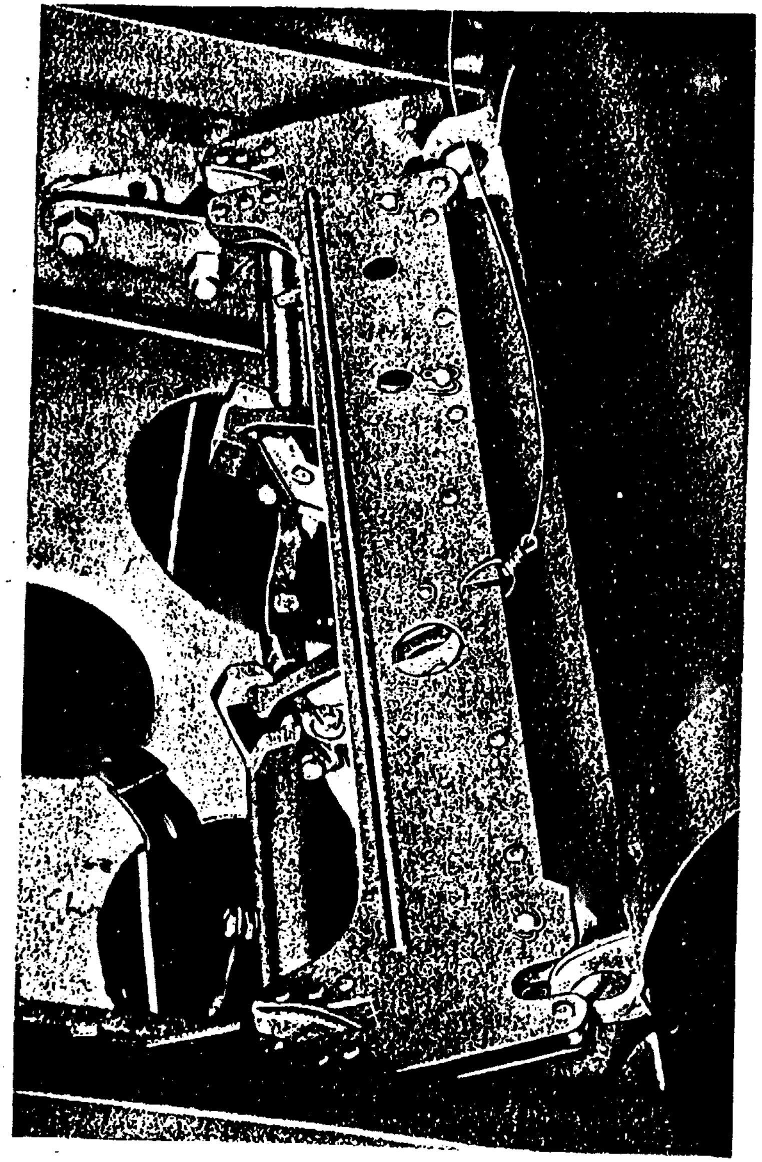


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Figure 273 — Loaded ADAPTER, Cluster, M3, Suspended in Airplane

Chapter 8

Practice and Drill Bombs

GENERAL.

Practice Bombs. Practice bombs are used during both peacetime and wartime. Their chief function is to enable Air Corps bombardiers to practice their marksmanship with bombs which resemble real bombs closely enough to assure that a hit with a practice bomb would be a hit with a real bomb. A secondary function is to give ordnance personnel practice in assembling, fuzing, and handling bombs.

Development. Practice bombs in contrast to other practice ammunition are not made by using the same case as the H.E. round and filling it with a spotting charge. Obviously it would be too expensive to drop large GP bombs, sand filled with a spotting charge and fuze added for practice. Therefore, the search for a cheap bomb was initiated.

The first real practice bomb used by the Army was water filled. This bomb had no spotting charge but depended entirely upon the resultant splash to inform the bombardier of his accuracy. This type was unsatisfactory for the following reasons:

The water froze at high altitudes.

The water moved and caused the bomb to waver in flight.

The splash could not be seen from high altitudes.

Another bomb was developed using sand and water as the filler. This gave the bomb added weight and prevented the water from swishing around during flight. To increase its visibility at the point of impact, a spotting charge was added in the tail end of the bomb. This was in the form of a smoke compound confined in a glass bottle. This compound on exposure to air immediately formed a cloud of smoke. However, it was found unsatisfactory because of the following:

The glass bottle burst at high altitudes.

The cap loosened under high pressure or temperatures.

The contents froze and broke the bottle at high altitudes.

In any of these cases, the plane became filled with smoke.

At this point, it was decided to use the empty bomb bodies of the Mark series from the first World War as practice bombs and at the same time to continue the search for a satisfactory cheap bomb. The Mark series used, consisted of bombs 17, 25, 40, 50, 100, and 300 pounds in weight. Sand, a spotting charge, a fuze (either nose or tail) and a primer detonator wherever necessary were added to the bomb body to make for a practice bomb.

Finally the 100-pound M38, later modified in several respects so as to become the M38A2, was developed as the standard practice bomb for demolition bombing. In the subsequent pages, the bombs

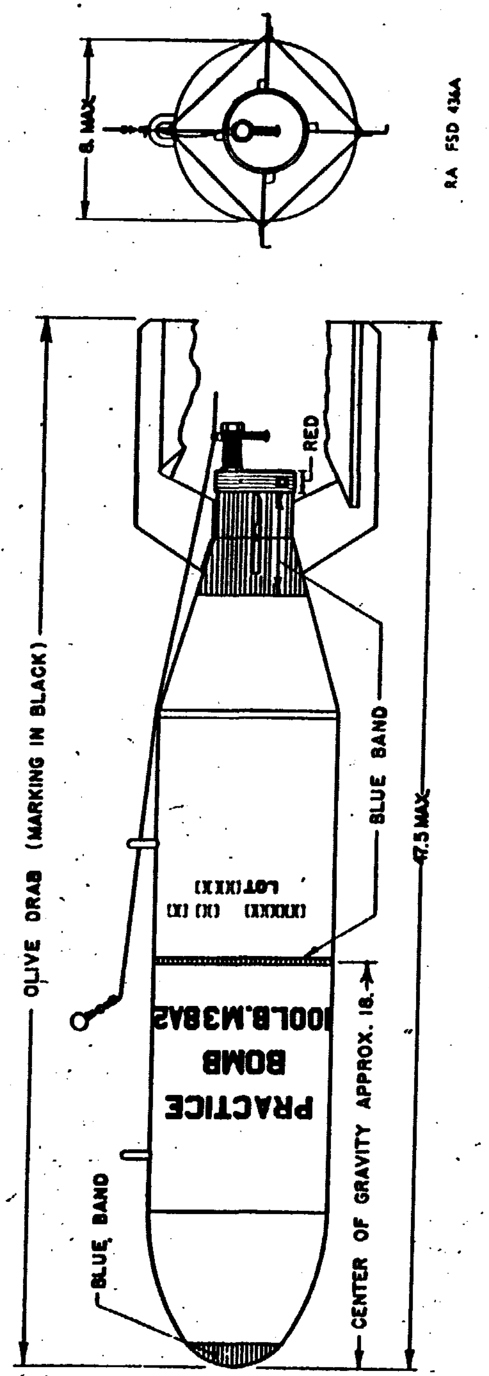

Figure 274 — BOMB, Practice, 100-pound, M38A2

discussed are those which are in use at the present time and were developed for practice in the use of specific types of service bombs.

Drill Bombs and Gage Bombs. Drill bombs are provided for training and practice in assembling, fuzing, handling, and loading on planes, and for the study of logistics. They are fitted with adapters to receive inert fuzes of standard models. Drill bombs are of the same size, shape, and weight as the corresponding service bombs. These bombs contain no explosive and are painted black or olive drab with black bands and are appropriately marked to distinguish them from explosive bombs.

Manufacturers of the various types of bombers and manufacturers of bomb racks are chiefly interested in gage bombs. These are either empty standard bombs or wooden forms used in the testing of planes for clearances, or in testing racks for capacity or proper function.

BOMB, PRACTICE, 100-POUND, M38A2.

General. This bomb is used to give practice in demolition bombing. It is a thin case bomb, easy to manufacture, cheap in cost, and accurate in use. The bomb case cannot be reused after it has once been dropped in practice.

Body Description. It is constructed of light sheet metal, approximately 22 gage. The body is formed by rolling a rectangular sheet of metal into the form of a cylinder 8 inches in diameter, and spot-welding the seam at 2-inch intervals. The rounded nose is pressed from the same metal, as is the tail which is formed in the shape of a cone. Inside of the smaller end of the conical tail section is welded the spotting charge receiver. It extends about 7 inches into the cone and projects about 2 inches out of the tail end. The inner end of this receiver is fitted with a shoulder which supports a thin metal cover which is inserted after sand loading to protect the spotting charge from the sand in the bomb. At the outer end of the receiver are two projecting ears which serve to lock the spotting charge in place.

The receiver may be equipped with a cover cap. This is sometimes removed because it tends to stick tightly and make insertion of the spotting charge difficult in the field. Since the bombs are protected from the elements by at least a tarpaulin, this procedure does not appreciably harm the bombs.

Two suspension lugs are bolted to the bomb body during fabrication. The tail portion ends in a box type tail fin which has one blade in line with the suspension lugs. The over-all length of the bomb body is 47¼ inches. When empty, the bomb body weighs approximately 14 pounds. When completely loaded with sand (approx. 80 lb) and spotting charge, the weight of the bomb is approximately 100 pounds. The cost of the empty bomb body is approximately $1.50. When

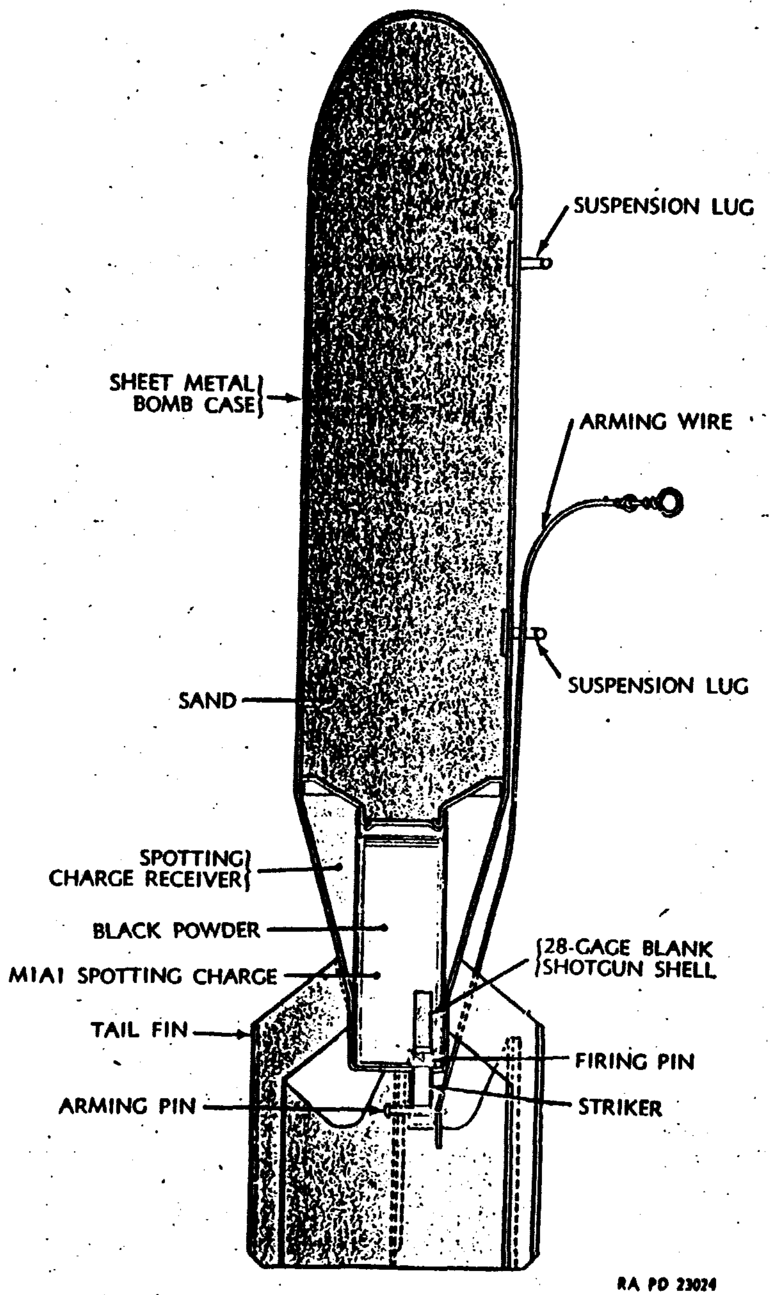

Figure 275 — BOMB, Practice, 100-pound, M38A2—Sectioned

completely loaded, the cost of the complete round is approximately $3.00. It receives the M1A1 Spotting Charge which houses both the spotting charge and firing mechanism. The Suspension Band M1 is provided for single suspension. The band is a separate component.

CHARGE, Spotting, M1A1. The M1A1 Spotting Charge is used to provide a charge and a firing mechanism. It is made from a large size tin can which has 3 pounds of black powder assembled loosely within. At the top of the can is a cover which has a hole in it for the insertion of a 28-gage blank shotgun shell and firing mechanism. The blank shotgun shell serves as a primer and igniting charge.

The firing mechanism consists of a fuze housing which has within it a striker held in position by an arming pin. Below the striker is a separate firing pin. The arming pin is always being forced outward by its spring but it is held in position by a cotter pin or arming wire located in one of the two eyelets in the small end of the arming pin. A small freely fitting sleeve is assembled over the end of the arming pin which is held in place by a cotter pin in the outer of the two holes. This sleeve makes the cotter pin more accessible and provides for proper arming wire resistance. It is important that this sleeve is always in place and that it is a loose fit on the arming pin. An inner hole through which the arming wire is threaded is exposed by a slight pressure on the head of the arming pin. The complete assembly is moistureproof and must not be disassembled under any circumstances. It is painted red with black stencil.

To assemble the spotting charge, about 80 pounds of sand is first added to the bomb. This requires filling to within ¼ inch of the receiver with sand. No water is ever to be added to the sand. The receiver cover disc is then inserted and the spotting charge is placed in the receiver so that the cotter pin is alined with the two suspension lugs. The two holes in the spotting charge cap are alined with the two ears projecting from the receiver sleeve. A slight force will cause the spotting charge cap holes and receiver ears to engage. A wooden tool is used to facilitate this action. This prevents longitudinal or rotational motion of the spotting charge in the receiver. The arming wire is placed through the inner hole of the arming pin after being threaded through the rear suspension lug. The arming wire is adjusted so as to protrude 2 to 3 inches beyond the arming pin. No safety clip is to be used.

Function. The bomb is dropped and the arming wire is retained in the plane. The arming pin ejected by its spring allows the striker to move down and come to rest on the firing pin.

On impact, the force of inertia causes the striker to move down against the firing pin. The firing pin strikes the primer of the 28-gage blank shotgun shell, igniting it. The flame produced ignites the igniting charge in the blank shotgun shell which in turn ignites the black

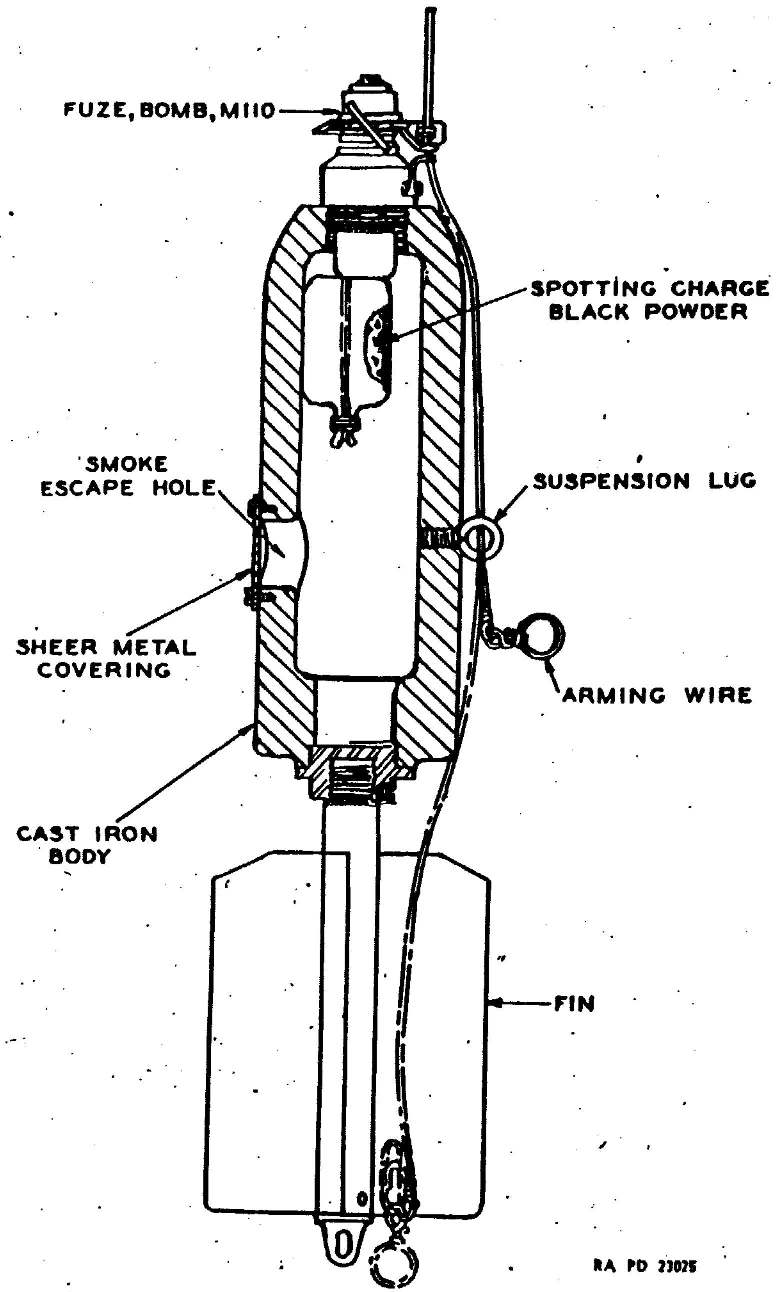

Figure 276 — BOMB, Practice, 20-pound, M48

powder spotting charge. The black powder produces a puff of white smoke at the point of impact to indicate where the bomb has struck. The bomb body is not reusable after dropping.

Packing. The bombs are packed 1 per cardboard container, empty. The spotting charges are packed 20 to the box. They are shipped separately.

Complete Round Components. Components necessary for a complete round consist of the following:

BOMB, practice, 100-pound, M38A2, less spotting charge
CHARGE, spotting, assembly M1A1, Practice Bomb, 100-pound, M38A2
Wire, arming, type A

BOMB, PRACTICE, 20-POUND, M48.

General. This bomb is designed to give practice in high-altitude fragmentation bombing. The bomb body may be reused after it has been dropped in practice unless it is badly damaged.

Description. The bomb body is cylindrical in shape and is made of heavy cast iron. To the rear of the bomb body, a hole in the side of the bomb, covered by a sheet metal disc is provided to allow for the escape of smoke. Opposite the hole on the other side of the bomb body is a lug for horizontal suspension. The nose is threaded to receive the M110 or the AN-M110A1 Bomb Nose Fuze. The body is hollow and receives a spotting charge of 0.13 pound of black powder. The rear of the bomb body is closed by means of a threaded cap. The cap is also threaded to receive the fin assembly. The fin assembly is bladed and the same as that of the 20-pound AN-M41 Fragmentation Bomb. Attached to the fin assembly is a lug for vertical suspension of the bomb. The fin is held securely to the threaded cap by means of a set screw. The over-all length is 21.7 inches. The total weight with spotting charge (no inert filler is used) is 20.5 pounds.

Function. In function, it acts exactly as the 20-pound AN-M41 High-altitude Fragmentation Bomb using the same fuze. The cluster is dropped and the arming wire is retained in the plane. The cluster opens and the bombs drop out. After several hundred revolutions of the vane, the fuze will arm. Upon impact, the fuze will function the black powder spotting charge. The smoke produced will blow out the metal disc and will show a white puff at the point of impact. The bomb body may be reused although the other components, fuze and spotting charge, must be replaced.

Packing. The bombs are packed in clusters, six bombs per cluster. Cluster Practice Bomb M2 is similar to the Fragmentation Bomb Cluster M1 except that six practice bombs replace the six fragmentation bombs. Cluster Practice Bomb M2A1 is similar to the Fragmentation Bomb Cluster AN-M1A1 with the same difference as described for the M1 and M2 Clusters.

Complete Round Components. A complete round consists of the following components:

BOMB, practice, 20-pound, M48, unfuzed without spotting charge assembly
CHARGE, spotting, assembly, PRACTICE BOMB, 20-pound, M48
FUZE, bomb, M110 or AN-M110A1 (nose)
Wire, arming, type A

BOMB, PRACTICE, 17-POUND, M37.

General. This bomb is designed to give practice in low-altitude parachute fragmentation bombing with or without the use of a fuze. The bomb is designed for reuse after it has been dropped.

Description. The bomb body is cylindrical in shape and is made of cast iron. Near the nose of the bomb body are two diametrically opposed holes leading into the bomb body. These holes allow for the escape of smoke from the spotting charge. At the center of gravity (6.13 inches from the nose) will be found a lug for horizontal suspension. The nose is threaded to receive the M104 Practice Bomb Nose Fuze or a closing plug. This fuze is similar to the M104 Fuze previously described except for the omission of the booster cup and charge of tetryl. The body is hollow and receives a spotting charge assembly weighing 0.75 pound. The rear of the bomb body is closed by means of a threaded cap. The cap is threaded to receive the same parachute assembly as the 20-pound M72 Fragmentation Bomb. Attached to the parachute case are wires which end in a lug for vertical suspension. The parachute case is held securely to the threaded cup by means of a set screw. The over-all length is 29.4 inches. The total weight with spotting charge (no inert filler is used) and fuze is 22.5 pounds.

Function. In function, it acts similarly to the 23-pound, M72, Low-altitude Parachute Fragmentation Bomb dropped without cluster. The bomb is dropped and the parachute opens arming the fuze. Upon impact, the firing pin initiates the detonator charge in the fuze (no booster) which in turn functions the spotting charge located at the rear of the bomb body. The smoke produced will blow out from the holes in the bomb body, producing a puff of smoke at the point of impact. The bomb body and parachute case may be reused although the other components, fuze and spotting charge, must be replaced.

NOTE: Since the parachute is ample for spotting purposes, the fuze and spotting charge are no longer used.

Packing. The bomb bodies, parachute units, fuzes, and smoke charges are shipped separately. The bomb bodies are packed four to a wooden box, whereas the parachute assembly is packed eight to a wooden box.

Complete Round Components. A complete round consists of the following components:

BOMB, practice, 17-pound, M37
PARACHUTE and CASE assembly for 17-pound Practice Bomb M37

BOMB, PRACTICE, 23-POUND, M71.

General. This bomb is designed to give practice in low-altitude parachute fragmentation bombing using an adapter cluster.

The bomb consists of the 23-pound M40 Bomb Case and parachute assembly. The bomb case is empty, and in place of a nose fuze, a nose plug is inserted. It is dropped from a cluster in the same manner as the 23-pound M40 Bomb. The open parachute lying on the ground after dropping provides a simple and efficient means of identifying where the bomb struck. All parts of this bomb are reusable.

It is packed in clusters, three bombs to the Adapter Cluster M3 previously described. The entire practice bomb cluster is designated as the M5 and differs from the M4 Fragmentation Bomb Cluster in that three practice parachute bombs replace the three fragmentation parachute bombs and no fuzes are used.

BOMB, PRACTICE, 23-POUND, M73.

General. This bomb is designed to give practice in low-altitude parachute fragmentation bombing, using bombs suspended singly.

This bomb consists of the 23-pound M72 Fragmentation Bomb Case and parachute assembly. The bomb case is empty, and in place of a nose fuze, a nose plug is inserted. It is dropped in the same manner as the 23-pound M72 or as the 17-pound M37 Practice Bomb. The open parachute lying on the ground after dropping provides a simple and efficient means of identifying where the bomb struck. All parts of this bomb are reusable.

BOMB, PRACTICE, 3-POUND, AN-MK. 5 MOD. 1.

General. This bomb is designed to give practice in low-altitude bombardment. It is particularly used for dive bombing practice on water or land. The bomb is rugged enough to allow for reuse after it has been dropped.

Body Description. The bomb body is streamlined or tear drop in shape, having a blunt nose and a tapered tail. It is made in one piece zinc alloy casting. An axial hole somewhat wider at the nose portion, extends through the bomb and is approximately 0.9 inch in

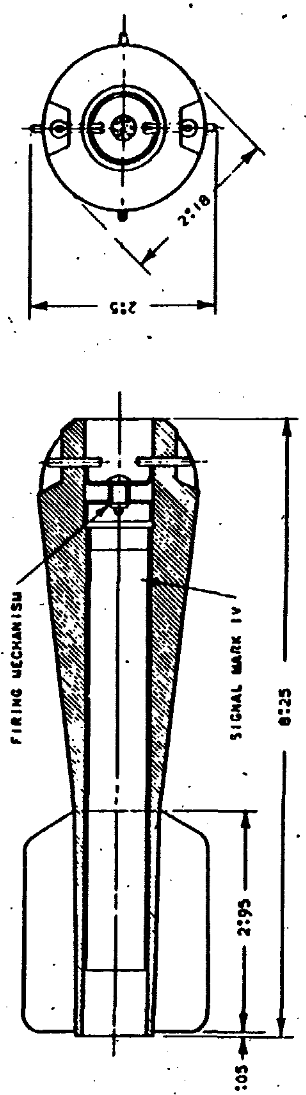

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Figure 277. — Practice Bomb Mk. V (Miniature—Navy)

diameter. A tail fin which consists of four blades is part of the body. There is no suspension lug on the bomb body. At the nose, a firing mechanism and blank shotgun shell is assembled to provide for a puff of white smoke. The entire length of the bomb body is about 8 inches. The total weight of the bomb body is approximately 2.7 pounds.

Firing Mechanism and Spotting Charge. The firing device consists of two shallow cups separated by a spacer. The firing pin extends through the bottom of one cup. The firing mechanism is held in place at the nose by a cotter pin which passes through holes in the bomb body above the firing pin and thereby prevents it from falling out through the nose and by a shoulder produced by the axial hole becoming smaller in diameter to prevent it from dropping out through the tail of the bomb body.

The Signal Cartridge AN-Mk. 4 consists of a long 10-gage blank shotgun shell 5.75 inches long containing an ejection charge and a pyrotechnic charge which burns above water after impact, forming a large puff of white smoke. To assemble the cartridge, it is only necessary to remove the cotter pin and firing pin assembly. The cartridge is then inserted. It is held by the flange on the brass base of the cartridge coming in contact with the shoulder of the bomb body. The firing pin assembly, having the firing pin directly above the primer of the cartridge, is replaced. The cotter pin is next inserted through holes in the nose of the bomb body to prevent the entire assembly from dropping out. No arming wire is used.

Function. The bomb is dropped, and on impact, the firing pin strikes the primer of the cartridge. The flame produced ignites the black powder which in turn expels a puff of white smoke through the tail of the bomb body to indicate the point of impact. The bomb body is reusable.

Packing. *The bomb body and signal cartridge are shipped separately.* The bomb bodies are shipped with the firing mechanism assembled to the bomb, 25 per crate. The signals are packed in a paper carton, 20 per carton, 20 cartons are packed per wooden box.

Complete Round Components. A complete round consists of the following components:
BOMB, practice, 3-pound, AN-Mk. 5 Mod. 1
BOMB, signal, practice, AN-Mk. 4

Comparison to Other Models. The AN-Mk. 5 Mod. 1 can be compared to a number of other miniature practice bombs as follows:

AN-Mk. 5. This bomb has a firing mechanism which is less sensitive.

M36. This bomb is the same as the AN-Mk. 5. It is made of a one piece die casting. It utilizes the M4 and M5 Blank 10-gage Shotgun Shell. The M4 has more powder and is used for high altitudes.

AN-Mk. 23. This bomb is 3 pounds in weight, made of cast iron.
AN-Mk. 43. This bomb is 4 pounds in weight, made of lead, and suited for glide and dive bombing. It conserves zinc.

FURTHER REFERENCES: Ordnance Drawings; TM 9-1980, Bombs for Aircraft; TM 3-330, Incendiary Bombs; OS 9-18, Ammunition, General; Ordnance Pamphlet No. 878; Ordnance Pamphlet No. 736; TM 9-1900, Ammunition in General; Pamphlet No. 2, Chemical Warfare; The Ordnance Sergeant; Complete Round Chart No. 5981; O.O. 7224, Ordnance Safety Manual; OS 9-49, Aircraft Depth Bomb Mk. XVII.

SECTION VIII.

MILITARY PYROTECHNICS

Chapter 1

Pyrotechnics

GENERAL.

Pyrotechnics are modifications of fireworks designed to produce a brilliant light for illumination, or to produce colored lights or smoke for signaling.

Some pyrotechnics were originally designed to be projected from or used on the ground; others to be released from or fired from aircraft. Accordingly they are classified as:

1. Ground types.

2. Aircraft types.

Further, pyrotechnics are classified according to the purpose for which they are intended:

1. Illumination.

2. Signaling.

Illumination may be necessary for:

1. Reconnaissance.

2. Observation.

3. Bombardment.

4. Landings.

Signaling may involve sending messages from aircraft to other aircraft, or to ground units. On the other hand, it may involve sending messages from ground troops to other ground troops, or to aircraft.

Pyrotechnic Flare Composition. In general, pyrotechnic compositions may be said to be mechanical mixtures of chemical compounds and elements. The action produced is an incandescence of the gases and of the small particles of solids carried by the gases. These substances, by virtue of their chemical composition, radiate much more light of the desired wave length than inert materials heated to the same temperature.

Chemical Characteristics. Since the composition is pressed into the form of candles, and burns progressively from one end to the other, oxygen of the air is not sufficient to support rapid combustion. Therefore, the mixture must contain an oxidizing agent for combustion, as well as a fuel. When subjected to pressure, the mixture must be sufficiently coherent to remain in compact form, so a binding agent is necessary. If the composition is to yield a colored flame, it may be necessary to include a color-intensifying compound. This compound must not affect the thermochemical reaction as a whole, but should influence the spectral distribution of the flame. In order to obtain the desired results, the burning rate must be kept within controllable limits. A retarding agent is needed for this purpose. Finally, as the composition must be protected against the absorption of moisture, a waterproofing agent is required. As some materials serve more than one purpose, each composition does not contain single ingredients serving each of the purposes mentioned.

The ingredients used in pyrotechnic flare compositions may be classified as fuels, oxidizing agents, color intensifiers, retardants, binding agents, and waterproofing agents. Typical ingredients in the classification are as follows:

1. Fuels. Provide combustible material: magnesium; aluminum; sulphur; asphalt; resinates of calcium, barium strontium, copper.

2. Oxidizing agents. Provide oxygen for combustion: perchlorates of potassium and ammonium; chlorates of potassium and barium; nitrates of potassium, barium, strontium, sodium; chromates of strontium and barium.

3. Color intensifiers. Add color to flame: chlorides of barium, strontium, copper; nitrates of strontium, sodium.

4. Retarding agents. Control burning rate: asphalt, paraffin, sulphur, resinates of metals.

5. Binding agents. Hold composition together: asphalt, paraffin, sulphur, resinates of metals.

From this tabulation, it is obvious that in some cases a single material will serve more than one purpose.

Factors Influencing Candlepower and Burning Rate.

1. Percentage compositions.

The addition of an ingredient may increase or decrease the candlepower and burning rate, depending on its chemical characteristics. For example:

Color-intensifying agents which are also oxidizing agents can be used to increase the candlepower and burning rate. Color intensifiers which are neither fuels nor oxidizing agents reduce the candlepower and burning rate while improving the color value.

2. Granulation of ingredients.

If a given composition is prepared from ingredients having certain granulations, and this is formed into a candle under a prescribed uploading pressure, combustion will take place at a controlled rate. This will result in definite pyrotechnic characteristics. It has been found that if the granulation of one or more ingredients is changed, the chemical reactions involved in the burning are retarded or accelerated, and the pyrotechnic values are affected. In general, decrease in size of particles increases the candlepower and increases the burning rate.

3. Density of loading (pressure)

It has also been found that the pressure under which a composition is formed into a candle affects the pyrotechnic characteristics. However, increased pressure brings about an increase in candlepower and a reduction in burning rate.

4. Diameter of candle (burning area).

Taking the same quantity of composition and forming, at constant pressure, candles of increasing diameters it has been found that an increase in diameter will cause an increase in candlepower and an increase in burning rate for the candle as a unit. This is naturally due to more exposed burning area.

Stability of Pyrotechnic Flare Compositions. The stability charactristics of pyrotechnic compositions as a class present a problem of major magnitude. This is due to the fact that ingredients, which in themselves may be quite stable, may prove extremely unstable when mixed with certain other materials.

Magnesium and aluminum are excellent fuels because each burns with a white light which is accompanied by the formation of a refractory oxide. Magnesium is superior to aluminum in these respects. However, each undergoes oxidation on exposure to air or moisture, magnesium being more easily oxidized than aluminum. In the case of aluminum, it appears that the thin film of oxide formed in early stages of oxidation acts as a protective coating. Magnesium, however, must be protected by a thin film of chemically inert material, such as paraffin.

Anhydrous strontium nitrate is hygroscopic, but normally stable. However, it has been found that when composition containing 40 percent strontium nitrate, 15 percent strontium chromate, 9 percent strontium chloride, 10 percent strontium resinate, 26 percent magnesium, coated, are subjected to storage at 50 C, there is no deterioration. However, at magazine temperatures there is a very definite deterioration within 9 months. Deterioration is accompanied by the formation of ammonia, indicating reduction of the nitrate by the magnesium. The reaction has been ascribed to temperature fluctuations, causing condensation of moisture or dehydration of the crystalline strontium chloride resulting in reaction between the nitrate and magnesium.

Slight volatility of a solid ingredient may cause the deterioration of a pyrotechnic composition.

Peroxides such as those of barium and strontium are oxidizing agents and color intensifiers. There is some evidence that, unless compositions containing these are protected from atmospheric moisture, this causes the reduction and hydration of the peroxide and consequent deterioration of the composition.

The stability of the newly developed pyrotechnic composition must, therefore, be established by storage at different temperatures with periodic tests. This is usually done by placing candles, in waterproofed paper cases, into a magazine subjected to climatic temperature variations. In some cases, the composition is also stored in an unpressed condition.

It is therefore important, in developing pyrotechnic compositions, to utilize ingredients which are nonhygroscopic, nonvolatile, nonoxidizing at ordinary temperatures, and nonreactive with other compounds in the presence of moisture.

Also from the preceding discussion, it is possible to determine the following factors which influence the deterioration of pyrotechnic compositions:

1. Moisture.

2. Continued high temperature.

3. Sudden fluctuations in temperature.

Visibility of Pyrotechnic Signals. The range of visibility of pyrotechnic flame signals is determined by:

1. Candlepower.

2. Color.

3. Weather (including time of day).

It is an accepted fact that the greater the candlepower (amount of light), the greater the range of visibility, all other factors being equal.

The color of the flame also determines its range of visibility in accordance with its color wave length. Colors with shorter wave lengths (red) are absorbed by air more quickly than those with longer wave lengths (green).

The presence of moisture in air has a notable effect in reducing the visibility of signals. In clear weather, a light can be seen farther than during rain, snow, fog, etc.

The amount of light present also influences the range of visibility. Light can be seen farther at night than during the day.

FLARE, AIRCRAFT, PARACHUTE, M8A1.

Use. For emergency night landings or for landings on fields with insufficient ground illumination.

Description. Burning time = 3 minutes; candlepower = 400,000; weight = 17 pounds; and dimensions = 25½ inches long by 4¼ inches diameter.

Methods of Release. From vertical flare launching tubes; horizontal flare racks; internal bomb racks; and from external bomb racks.

Composition.

	Percent
Barium nitrate	33.7
Magnesium (linseed oil coat)	30.3
Aluminum	15.2
Sodium oxalate	18.8
Castor oil	1.0
Linseed oil	1.0

Construction.

Illuminant case. A convolute paper tube with $\frac{3}{16}$-inch walls encased in a zinc sheath 0.14 inch thick. The composition is pressed into this at a pressure of 3,600 pounds per square inch.

Nonglare effect. This is produced by use of sodium oxalate. This gives flame a yellowish tinge which reduces glare and also reduces contrast between light and shadow. It does not blind the pilot in the plane.

Inner construction. A fire clay seal is pressed into the case through the opening in the bottom; this prevents the friction igniters from igniting the candle at the upper end. The flare composition is pressed in increments against the fire clay seal. A first fire charge, composed of 75 percent flare composition and 25 percent black powder, is pressed in against the flare composition. A primer disc follows in line. This is a perforated disc with the perforations filled with black powder priming paste. A closing cover closes the open end and is fastened over a metal end reinforcing ring. This cover is merely pressed on, but it must be tight enough so that it cannot work free in handling. It must, however, be loose enough so that it can be blown off when the composition begins to burn. An aluminum base block is secured to the upper end of the illuminant case above the fire clay seal. This base block holds the illuminant case to the parachute case. Within the base block are two friction igniters which contain:

1. A primer cup which holds the friction composition (potassium chlorate, charcoal, and a dextrine binder).

2. A friction wire made in the form of a loop, coated with red phosphorus and running through the friction composition.

3. A tear strip of aluminum which secures the friction wire to the base block and insures that a good pull is necessary before the friction wire is drawn through the igniter.

The base block also serves as an anchorage for the suspension cable—shock absorber assembly.

A paper tube (the quickmatch housing) runs through the illuminant and carries a double length of quickmatch from the igniters to the primer disc.

Parachute case. Zinc metal made the same as the outside of the illuminant case.

1. Shipping cover. A metallic cover sealed with tear strip.

2. Hangwire cover. A dish-shaped metal container for the hangwire.

3. Hangwire. A means of initiating function of the flare on release from the plane.

4. Coupling. Connects hangwire and tear wire. Also provides means for the release of the hangwire cover from the hangwire, thus preventing its pounding against the plane after release of the flare.

5. Tear wire. A thin copper wire with a breaking test of 26 pounds. It serves to pull out parachute and release flare from the hangwire.

6. Pull-out cord. A cord 15 feet long. It pulls parachute out of parachute case.

7. Pilot disc. A cardboard disc which serves to aid in pulling the parachute out of the case in the event of failure of the tear wire.

8. Parachute. Made of silk. Substitutes are being used in view of the shortage of silk. 15 feet in diameter.

9. Shrouds. Cotton cord 14 feet long with a breaking test of 100 pounds.

10. Metal spool. This spool provides a means of joining the shrouds to the suspension cable.

11. Suspension cable. Composed of metal wire. It prevents the flame of the flare from igniting the shroud lines.

12. Shock absorber. Made by running the suspension cable through copper tubing and then winding the assembly into the form of a spring. It lessens the load on the parachute at the instant it opens by absorbing the sudden shock of retardation of the fall.

Operation of the Flare. Before installing the flare in the plane, the tear strip is removed, thereby enabling removal of the shipping cover. If the flare is placed in the vertical launching tube, it may rest on the ignition end of the illuminant or may be supported by the suspension hook, depending on the type of device used. If the flare is installed on a horizontal rack, it is supported by the suspension bands.

The swivel loop of the hangwire is attached to the arming pawl of the releasing device. When the flare is released, the hangwire cover is removed by the resulting jerk on the hangwire, and, by means of the pull-out cord, the parachute is withdrawn from the parachute case. As the flare continues its descent the load, or weight, of the flare breaks the tear wire, the flare is free of the plane, and the parachute opens. When the hangwire cover is pulled out of the parachute case, a spring, which is U-shaped and which serves to hold the coupling in the hangwire cover, is ejected. This releases the hangwire cover from the coupling. When the tear wire breaks, this allows the hangwire cover to drop free of the hangwire, and thus avoids the possibility of the cover battering against the plane in the air stream. The load suddenly applied to the shock absorber by the opening of the parachute pulls the friction wires through the friction composition, creating a flame which starts the ignition train. This flame is picked up by the double length of quickmatch and is carried down through the quickmatch housing where it is transmitted to the primer disc. The black powder in the perforations of the primer disc is ignited, and in turn carries the flame to the first fire charge. The first fire charge amplifies the flame and ignites the flare composition. With the ignition of the flare composition, a pressure is produced which blows off the closing cover of the flare and the operation is complete.

The interval of time required for full ignition of the flare after release is from 3 to 5 seconds.

FLARE, AIRCRAFT, PARACHUTE, M24.

Use. At present, for training in night bombing. Also substitute standard for night observation and bombardment.

Description. Length = 37 inches; diameter = 8.1 inches; weight = 44 pounds; burning time = 3-3½ minutes; and candlepower = 1,000,000 nominal.

Method of Release. From horizontal suspension.

Construction. *The body of the flare consists of a cylindrical case* formed from terneplate, having one end permanently closed by a pressed metal cap. The other end is provided with a removable cover which consists of a steel disc $\frac{1}{16}$-inch thick. To this disc is attached a light pressed metal cup which serves as a container for the hangwire. The disc is seated in an internal annular bead by three equally spaced indentations formed in the flare case. The hangwire assembly, which consists of a flexible steel cable $\frac{3}{32}$-inch in diameter having a steel ring attached to the free end, is provided for the purpose of removing the cover assembly when the flare is released from a plane. The hangwire assembly is not permanently attached to the cover assembly, but is anchored to it by means of a soldered stop on the end of the steel cable. The stop is seated on the outer face of the disc, in the channel formed by the hangwire container and the wall of the flare case. The cable is then passed through a notch in the disc, then underneath the cover, and out through a notch in the opposite side. The channel between the hangwire container and the flare case is filled with a sealing compound to waterproof the end of the flare. A tubular stop, crimped to the hangwire, rests on the outer face of the disc at the point where the hangwire projects outward from the flare. A notched turned-over portion of the hangwire container bears against the top of the tubular stop for the purpose of preventing

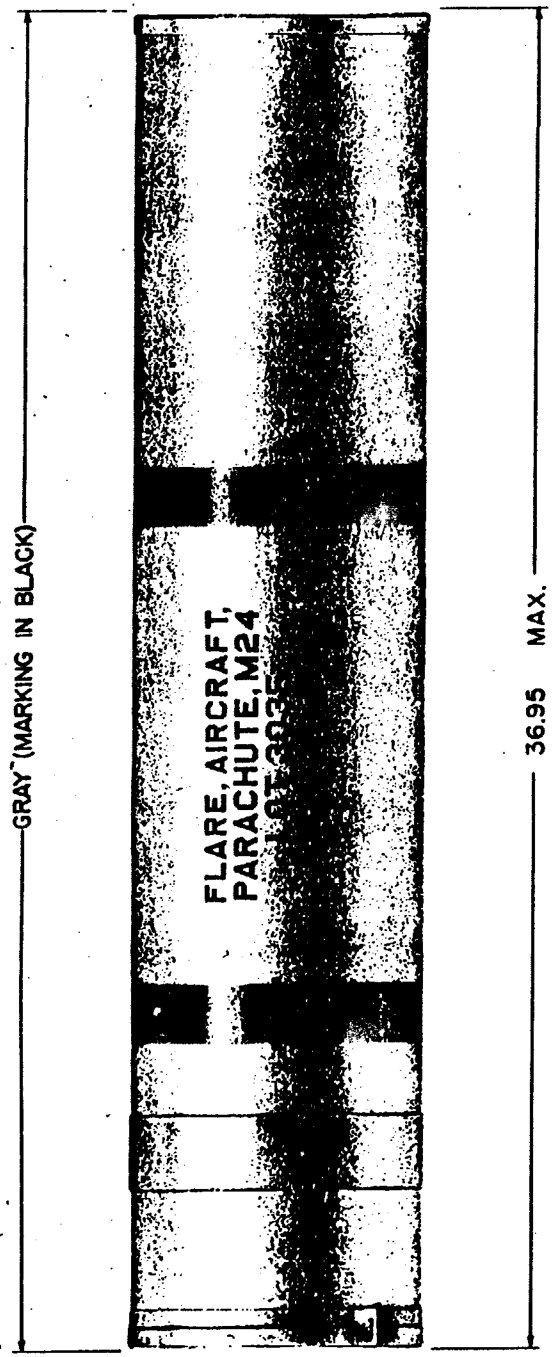

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Figure 278 — FLARE, Aircraft, Parachute, M24

longitudinal movement of the hangwire. Movement of the hangwire would tend to fracture the sealing compound. A copper sealing wire is threaded through holes provided in opposite sides of the flare case, over the cover assembly. The ends of the sealing wire are twisted together over the center portion of the hangwire container. The twisted ends are embedded in a lead seal, stamped with the letters "P.A." The purpose of the seal is to indicate whether or not the flare has been tampered with. A tear wire which connects the hangwire to the parachute pull-out cord is attached to that portion of the hangwire extending underneath the cover assembly. A shipping cover is assembled to this end of the flare and is secured to the flare case with adhesive tape.

The illuminant assembly is of the same design as that used in the M8A1 Flare, with the exception that the illuminant case is 22½ inches in length, which is 6¾ inches longer than the illuminant for the M8A1 Flare. The base block igniter assembly and the shock absorber assembly are the same types as those used in the M8A1 Flare. The illuminant composition consists of the same ingredients as used in the M8A1 Flare composition, the proportions of which have been adjusted to give a candlepower of approximately 1,000,000.

A shade, 58 inches in diameter, made from asbestos cloth, is attached to the illuminant assembly in order to screen the glare of the burning composition from the bombardier sighting on a target illuminated by the flare. The shade assembly consists of eight arms made from ⅜-inch seamless steel tubing to which the asbestos cloth shade is attached. The arms are hinged to a spider, and each is actuated by a rat trap type coiled spring. The shade assembly is secured to the upper end of the illuminant assembly with the same screws which hold the base block in the illuminant assembly. The M8A1 Flare type Parachute is attached to the illuminant assembly. A pull-out cord, approximately 12 feet long and attached to the crown of the parachute, is connected to the hangwire with a copper tear wire. Suspension bands are furnished with the flare for suspension from standard horizontal bomb racks.

Operation. Before installing the flare in the plane, the adhesive tape is removed, thereby enabling removal of the shipping cover. The ring on the hangwire is attached to the arming pawl of the releasing device. When the flare is released, the cover assembly is removed by the resulting jerk on the hangwire. The parachute is then withdrawn from the flare case by the pull-out cord. As the flare continues its descent, the load, or weight, of the flare breaks the tear wire, the flare is free of the plane, and the parachute opens. Due to the retardation of the fall caused by the resistance of the parachute, the flare case is stripped from the illuminant and shade assembly. At the same time, the resultant jerk pulls the friction igniters through

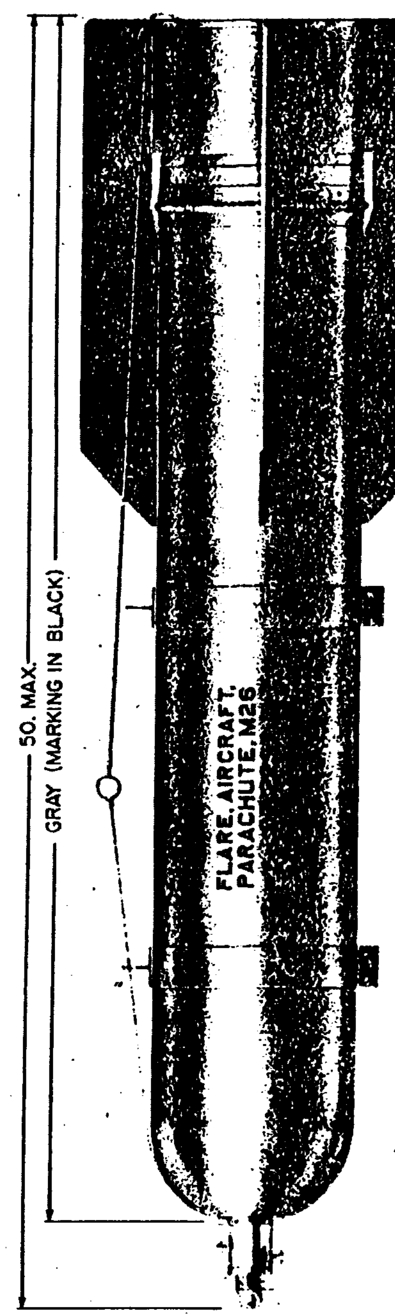

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Figure 279 — FLARE, Aircraft, Parachute, M26

the friction composition, thus creating a flame which is picked up by the double length of quickmatch. The flame passes down through the quickmatch housing to the primer disc by means of the double length of quickmatch. The black powder paste in the perforations of the primer disc carries the flame to the first fire charge which in turn ignites the flare composition. When the flare composition is ignited, the pressure which builds up causes the end closing cover of the illuminant assembly to blow out, releasing the rib retainer which is attached to it, and thus allowing the springs to open the shade.

The full time for the complete ignition of the flare after release is approximately 2 seconds. Both the cover assembly and the flare case drop to the ground. The cover assembly is released from the hangwire assembly to avoid the possibility of the cover battering against the plane in the air stream.

FLARE, AIRCRAFT, PARACHUTE, M26.

Use. To provide illumination for night bombardment.

Description. Length = 50 inches; diameter = 8 inches; weight = 53 pounds; burning time = 3-3½ minutes; candlepower = 800,000; substitute composition = 575,000.

The flare is equipped with the M111 Mechanical Time Flare Fuze which permits the function of the flare at 3,000 feet when released from aircraft at any altitude between 5,500 and 25,000 feet. The flare may be released from a plane traveling at any speed up to 200 miles per hour.

Method of Release. From horizontal suspension.

Construction. The flare case is cylindrical with a rounded nose, has tail fins, and the body has two suspension lugs attached for horizontal suspension. A shipping cover with a handle closes the tail end of the body, and is sealed by a strip of tape.

The inner construction is similar to the M24 Flare with the addition of the stabilizing sleeve, and the aluminum disk assembly which is functioned by the pressure built up by the functioning of the fuze.

Installation. Unscrew the fuze hole plug, screw the fuze in by hand, and seat it by hand force. Set the fuze to the desired time by loosening the thumb screw, rotating the body of the fuze until the desired number of seconds is indicated opposite the marker, then tighten the thumbscrew.

The cover is removed from the base of the flare and the outer end of the arming wire hangwire assembly is drawn from the hangwire container, taking care not to pull out the attached end of the hangwire. The hangwire is brought around the vane stiffener to the suspension side of the flare, and the arming wire is threaded through first

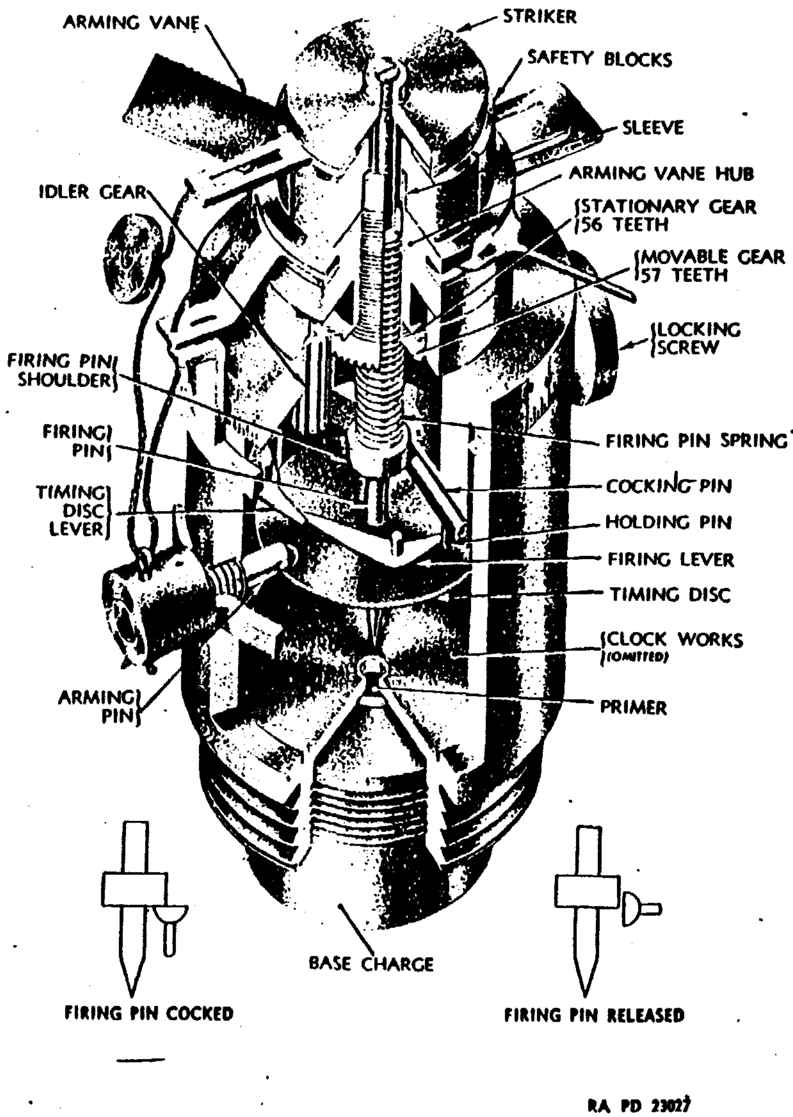

Figure 280 — FUZE, Flare, Mechanical Time, M111

the forward suspension lug, then the inner holes in the arming pin of the fuze, and finally through the inner holes in the vane stop. The flare is then installed in the plane and the ring of the arming wire hangwire assembly is attached to the arming pawl.

Operation. The flare may be released "safe" or "armed." If released "safe," it may function on impact. If released "armed," the following steps take place:

1. Movement downward withdraws the arming wire from the fuze allowing the vane to rotate to arm the fuze and, at the same time, allowing the arming pin to be ejected, thus starting the time mechanism.

2. When the flare has dropped the length of the hangwire, it breaks the seal wire, and pulls out the hangwire container which drops free. The tear wire, attached to the hangwire near its end, pulls out the tear-wire cord which, in turn, pulls out the stabilizing sleeve and its shrouds. A short length of cord attached to the shrouds removes the lock of the cover releasing cup.

3. When the flare has dropped this far, its momentum breaks the tear wire, allowing the flare to drop free. It is stabilized in flight by the fins and the sleeve. The arming vane on the fuze rotates to arm the fuze approximately 6 seconds after release.

4. At the time set, the fuze functions to push out the cover releasing cup. This releases the detachable cover to which the sleeve shrouds are attached, allowing the sleeve and cover assembly to separate from the flare and, by means of the parachute pull-out cord, to pull out the parachute.

5. The parachute opens and retards the fall of the flare with a jerk which:

Breaks the parachute pull-out cord, allowing the sleeve assembly to drop free.

Pulls the friction igniters through the friction composition, thus starting the ignition train of igniter, lead spitter fuze, quickmatch, primer, first fire, and candle. This is the same as the function of the M24, and reaches full ignition in approximately 9 seconds.

Pulls the flare assembly out of the case allowing the case to drop free.

6. As the candle ignites, it expels the rib retainer, as in the M24, allowing the rib springs to open the shade.

7. The flare burns for 3 to 3½ minutes with a light of 800,000 candlepower while dropping at an average speed of 11.6 feet per second.

FLARE, AIRCRAFT, PARACHUTE, M9.

Use. For reconnaissance. It is fired from Pyrotechnic Pistol M2 from a plane. It is not to be fired from a grounded plane.

AMMUNITION INSPECTION GUIDE

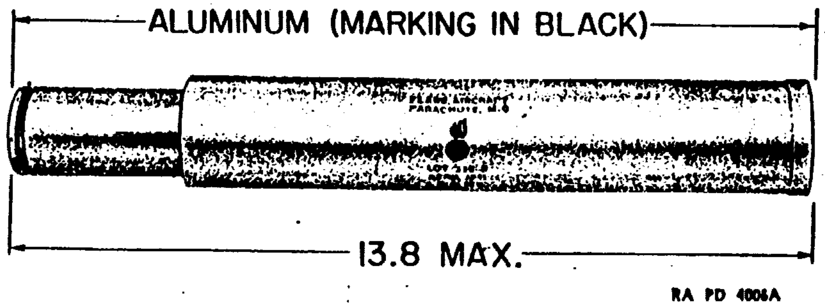

Figure 281 — FLARE, Aircraft, Parachute, M9

Description. Length = 13.8 inches; diameter = 2 inches; weight = 1.9 pounds; burning time = 1 minute; candlepower = 60,000.

Construction. The body of the flare is an extruded aluminum case, reduced at the base to fit into the detachable barrel, which is also of aluminum but of a smaller diameter than the flare case.

An expelling charge cup, containing black powder for the expelling charge, is attached to the inner wall at the base of the flare case. The fuse train (2½-sec del.) is housed in a metal flanged tube and is secured to the base of the expelling charge cup. The inner end of the fuse is in contact with the expelling charge, and the outward end is exposed to the flame of the propelling charge. The propelling charge is contained in the breech of the detachable barrel.

The illuminant charge is contained in the candle case. This case is closed at the upper end by the candle case cap which provides a means of attaching the parachute wire. A felt washer between the candle and the parachute acts to keep the flame of the expelling charge from igniting the parachute.

The upper end of the signal case is closed with a closing cap of aluminum which is pressed over the signal case.

A percussion primer is inserted into the lower end of the detachable barrel.

Operation. The flare is first locked in the pyrotechnic projector and is then initiated by a continuous pull on the trigger which fires the primer of the detachable barrel. This ignites the propelling charge, and projects the flare from the plane through a distance of approximately 80 feet, and at the same time ignites the delay train. After 2½ seconds, the delay train burns through, igniting the expelling charge. The gases of this charge expel the candle and the parachute. At the same time, the expelling charge ignites the igniter charge of the candle; thus, the first fire charge and finally the flare composition is fully ignited.

The flare burns for approximately 1 minute with a candlepower of 60,000.

MILITARY PYROTECHNICS

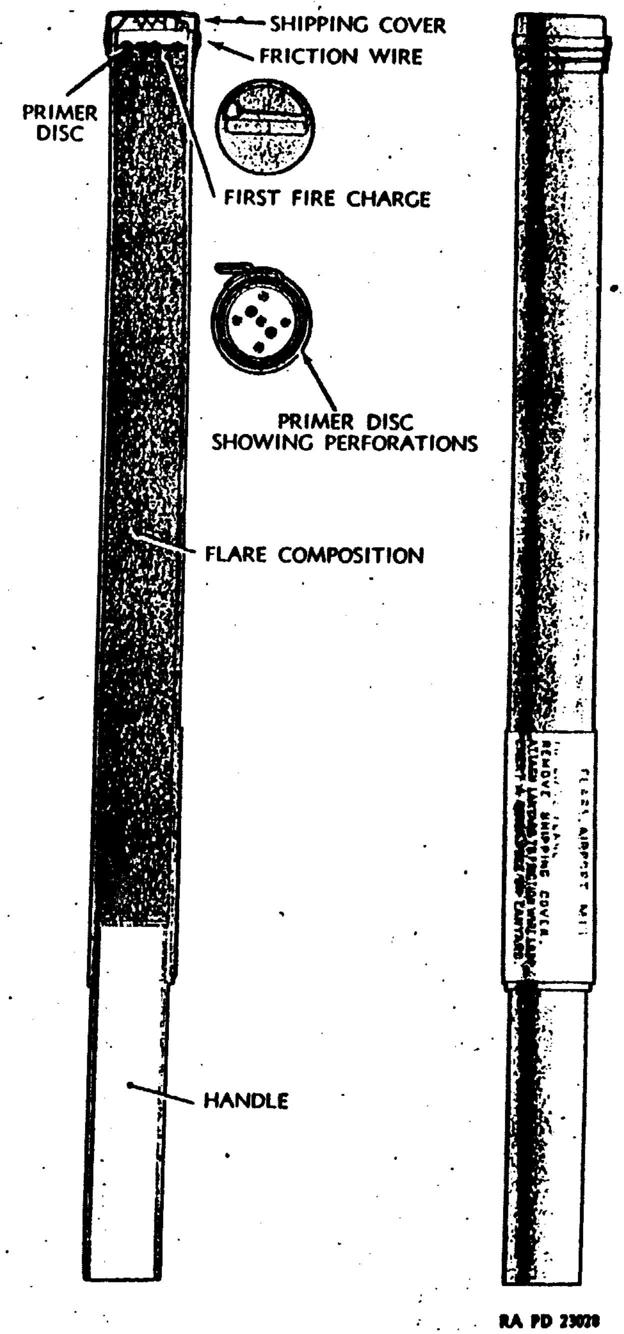

Figure 282 — FLARE, Airport, M13

FLARE, AIRPORT, M13.

Use. To provide illumination for night landings at emergency landing fields or in case of power failure at regular airports. It is operated from the ground.

Description. Length = 23 inches; diameter = $1\frac{3}{4}$ inches; burning time = 3 minutes; candlepower = 40,000.

Handle (hollow). Length = 7 inches; diameter = $1\frac{1}{2}$ inches.

Construction. The body is composed of chip board with a chip board closing plug at the lower end held in place by the hollow handle.

The flare composition is pressed in on top of the plug, followed by a first fire charge, and finally by a primer disc. Perforations in the primer disc are filled with black powder priming paste.

The single friction igniter is held at the top of the primer disc in a metal cap with a raised hollow ridge running through the center.

Operation. After removing the shipping cover, a lanyard is attached to the ring on the end of the friction igniter. A quick jerk on the lanyard causes the friction igniter to be pulled through the friction composition thereby starting a flame. The flame ignites the black powder priming paste in the perforations of the primer disc, which ignites the first fire charge. The first fire charge ignites the flare composition, and the flare is fully ignited.

The flare burns for approximately 3 minutes with a candlepower of 40,000.

Before operating this flare, it must be fastened onto a support which may, in turn, be fastened onto a post or planted firmly into the ground.

When using a flare of this description, it must be borne in mind that pyrotechnics will drip in operation; consequently, care must be exercised that no inflammable material is present around the flare that might become ignited by the drippings.

Substitute Flare. Overage M8A1 Flares may be substituted for the M13. In so doing, all the components above the metal spool are removed and the lanyard is attached to the metal spool.

A sharp pull on the lanyard will cause the friction igniters to be pulled through the friction composition and then the ignition train runs its regular procedure of quickmatch, primer, first fire, and flare composition.

BOMB, PHOTOFLASH, M23A1.

Use. Aerial night photography.

Description. Length = 25.4 inches; diameter = $4\frac{1}{4}$ inches; weight = 10.5 pounds. Contents = $7\frac{3}{4}$ pounds flashlight powder;

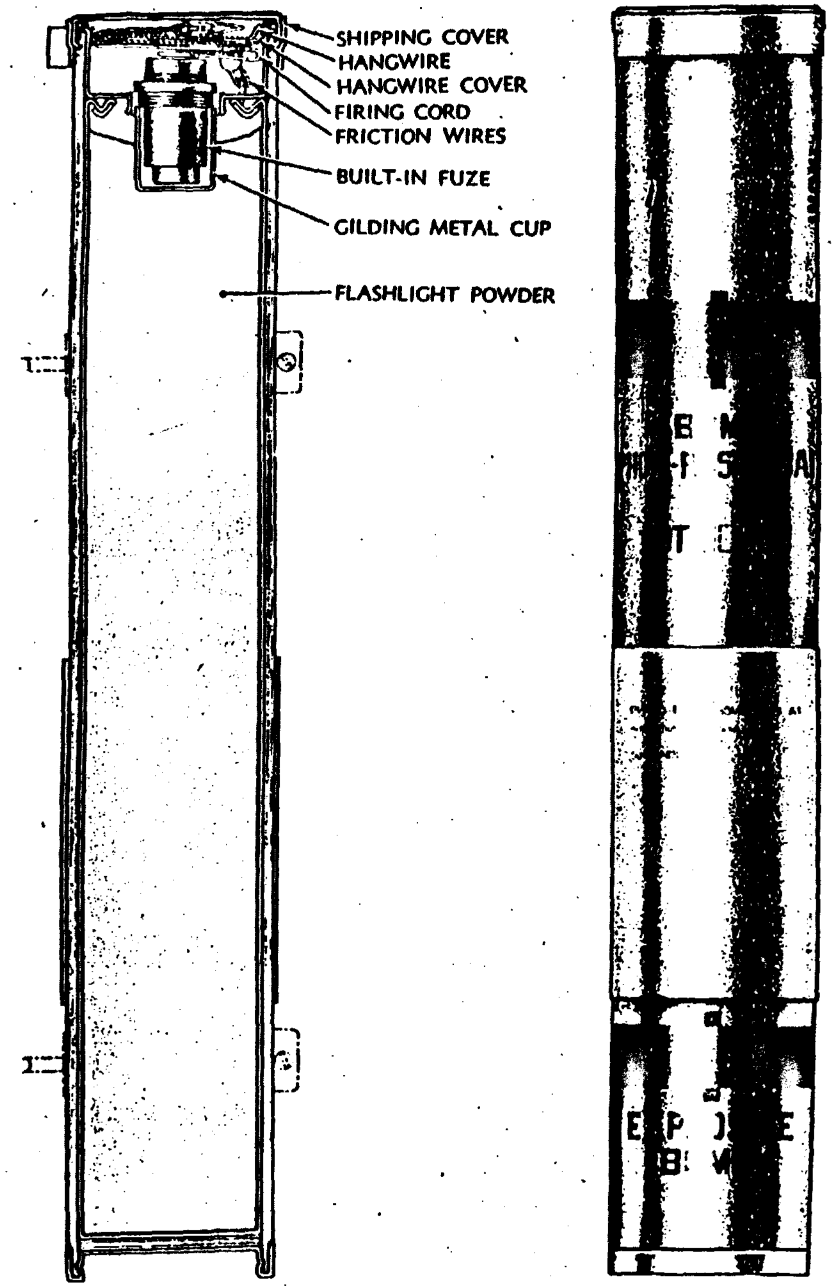

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Figure 283 — BOMB, Photoflash, M23A1

maximum candlepower = 303,000,000; average candlepower = 84,840,000; total burning time = 0.16 second.

Construction. The case of the photoflash bomb is of laminated paper, sealed at the lower end with a metal closing cup. The flashlight powder is placed inside the bomb body and kept in place by a metal partition cup which is secured to the body by rivets. This cup accommodates the adapter for the fuze, and is a seat for the hangwire container. The hangwire container is provided with a flange which is notched on opposite sides. The partition cup is also provided with corresponding notches to accommodate the portions of the hangwire which project through the notches in the hangwire container. The hangwire is made from flexible steel aircraft cable $\frac{1}{16}$ inch in diameter. The free end of the hangwire is provided with a swivel loop, the other end with a soldered stop. In assembling the hangwire container to the bomb, the end of the hangwire which is provided with the soldered stop is placed in a notch in the flange of the hangwire container. The hangwire then passes across the bottom of the hangwire container and projects outward through the other notch in the flange of the container. A ring is secured to that portion of the hangwire which passes underneath the container. A firing cord, which fires the fuze, is secured to this ring.

The design provides a delay of approximately 15 seconds from the release of the bomb to the ignition of the flashlight powder charge. The fuze consists of a body which houses an upper and lower time train ring assembly and two friction igniter assemblies. The friction wires are made from No. 1 braided picture wire. The ends of the friction wires, which project through the igniter cups, are coated with a red phosphorus paste. The igniter cups are loaded with a friction composition. At the outer face of the igniter cups, the friction wires are bent at right angles toward the center of the fuze, then twisted together. A thin aluminum disc, having a central hole, is pressed against the bent portions of the wire by the igniter retainer. The twisted ends of the wires project through the hole in the aluminum disc. The aluminum disc is a safety feature and, in operation, must tear or deform before the friction wires can fire the composition in the igniter cups. The coated ends of the igniter wires are formed in the shape of a helix, and in operation the helix must straighten out as the wires are drawn through the igniter cups, thus adding more resistance to the movement of the igniter wires. The twisted ends of the friction wires are run through a ring fastened to the firing cord and are attached to a staple secured to the partition cup.

Both time-train rings are loaded with compressed fuse powder, sealed with fire clay loaded into the fuze rings under pressure. The time trains of both rings burn both ways from the point of ignition

to a flash hole which is opposite the point of ignition. Thus, in effect, each time ring has two separate delay elements. A piece of quickmatch is used to ignite the upper time-train ring from the flame produced by the friction igniters. The flame from the upper ring is relayed to the lower ring by another piece of quickmatch. The time-train rings are separated by a spacer to facilitate venting. The lower ring contains a base charge which consists of 50 grains of grade A4 black powder. The ignition of this charge ignites the flashlight powder charge.

Operation. The outer cover is first removed; then the bomb is installed in the plane. The swivel loop on the end of the hangwire is secured to the arming pawl of the releasing device. When the bomb is released, the resulting jerk on the hangwire removes the hangwire container. As the bomb continues to fall, the friction igniters are fired by means of a jerk on the firing cord. The jerk removes the phosphorus coated ends of the friction wires from the igniter cups. The free ends of the friction wires slip through the ring on the firing cord and the bomb is free from the plane. The hangwire and firing cord remain attached to the releasing device. The hangwire container, which is not permanently attached to the hangwire, falls to the ground. The hangwire container is designed to automatically detach itself from the hangwire to prevent the container from battering the plane due to the force of the air stream. Because the twisted ends of the friction wires are secured to the partition cup, the wires remain with the bomb.

The flame from the friction igniters is picked up by the first length of quickmatch, and transmitted to the upper time-train ring. This ring burns in both directions around to the flash hole, where the flame is picked up by the second strip of quickmatch and carried to the lower time-train ring. This ring also burns in both directions to its flash hole where the flame passes through to ignite the black powder base charge. The blast from the base charge ruptures the adapter cup and ignites the flashlight powder charge. The time of delay of the fuze is 15 seconds.

The bomb burns for 0.16 second with a maximum candlepower of 303,000,000, and an average candlepower of 84,840,000.

BOMB, PHOTOFLASH, M46.

Use. For high-altitude night photography.

Description. Length = $45\frac{1}{2}$ inches; diameter = 8 inches; weight = 51.9 pounds. Contents = 25 pounds flashlight powder; maximum candlepower = 1,000,000,000.

Construction. This photoflash bomb is equipped with the M111 Mechanical Time Flare Fuze which permits the function of the bomb

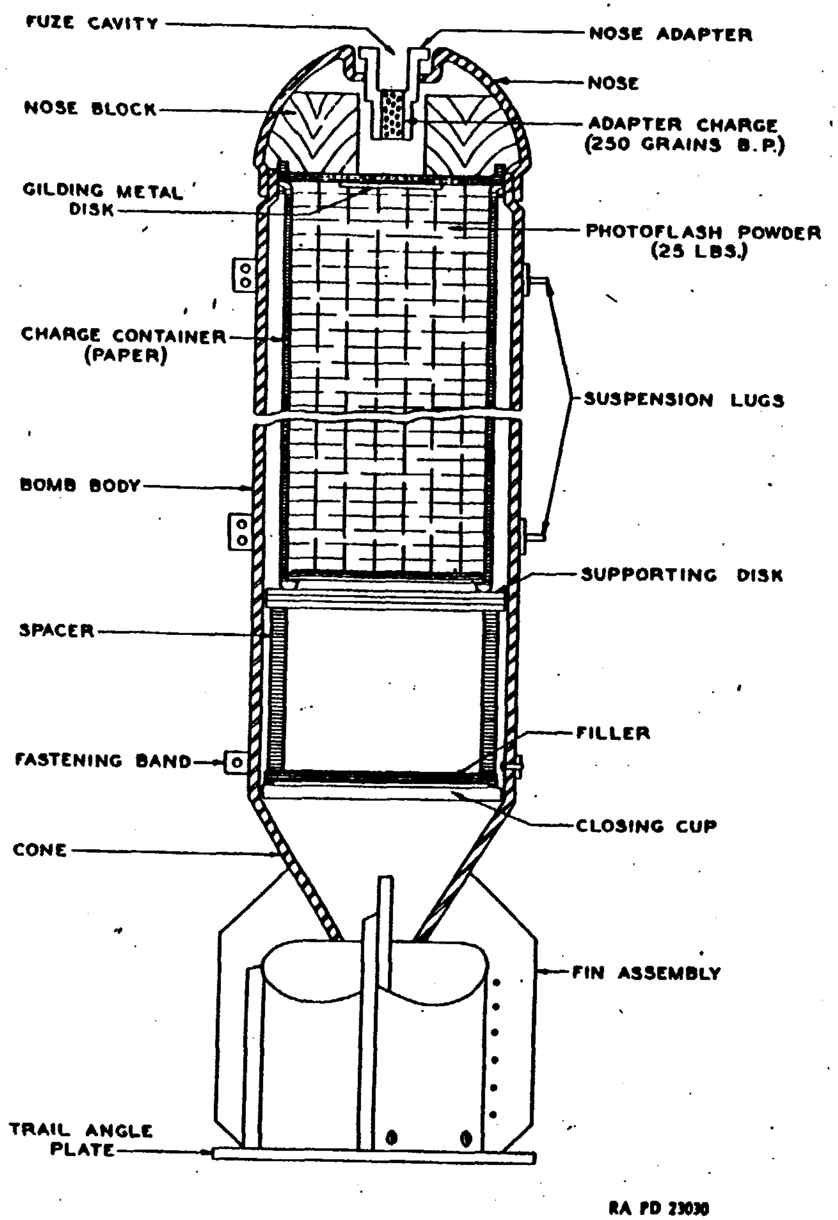


Figure 284 — BOMB, Photoflash, M46

at 3,000 feet when released from aircraft at any altitude up to 20,000 feet.

In appearance, the bomb resembles the 100-pound, M47 Chemical Bomb. It consists of a thin sheet steel cylindrical body to which a rounded nose and tail assembly are attached.

Into the nose section of the bomb is welded a steel nose adapter having a fuze cavity for the M111 Pyrotechnic Fuze, and containing in its base an explosive charge of 140 grains of black powder. Inside the bomb body, and directly below the adapter charge, is the cardboard container with 25 pounds of photographic flashlight powder. The top of this container is closed with a thin gilding metal disc, and the bottom is closed with crimped, sheet metal terneplate. This charge container is only 24 inches long and does not fill the entire bomb body. It rests on a plywood supporting disc which is held by a cardboard spacer in its proper place with respect to the strawboard filler and the sheet metal body closing cup.

The tail assembly is spot-welded together, and to the sheet metal cone section. The cone is attached to the rear end of the bomb body by means of three slotted grooves which lock around corresponding riveted lugs on the bomb body, and is held there by the fastening band. Attached across the back of the fin assembly is the flat trail angle plate, held by two ¼-inch carriage bolts running through the fins.

Operation. After proper fuzing and the insertion of the arming wire, the bomb is suspended in the bomb rack by use of a standard B-7 type shackle attached to the suspension lugs.

On release from the plane, the fuze arms in several seconds, and then functions at the predetermined time according to the altitude of the plane. When the fuze functions, the 70-grain black powder booster in the fuze sets off the 140-grain adapter charge in the bomb. The pressure set up by the adapter charge ruptures the gilding metal disc and ignites the flashlight powder charge.

TYPES OF SIGNALS.

General. Of the original class of aircraft signals, all except the SIGNAL, aircraft, red star, parachute, M11 have been reclassified as standard for issue only, while the M11 is still standard for issue and manufacture.

In January 1942, the Ordnance Department standardized a series of signals now referred to as the "Interim" type. This series consisted of six double star and three single star signals.

1. SIGNAL, aircraft, double star, Red-red, AN-M28.
2. SIGNAL, aircraft, double star, Yellow-yellow, AN-M29.
3. SIGNAL, aircraft, double star, Green-green, AN-M30.
4. SIGNAL, aircraft, double star, Red-yellow, AN-M31.

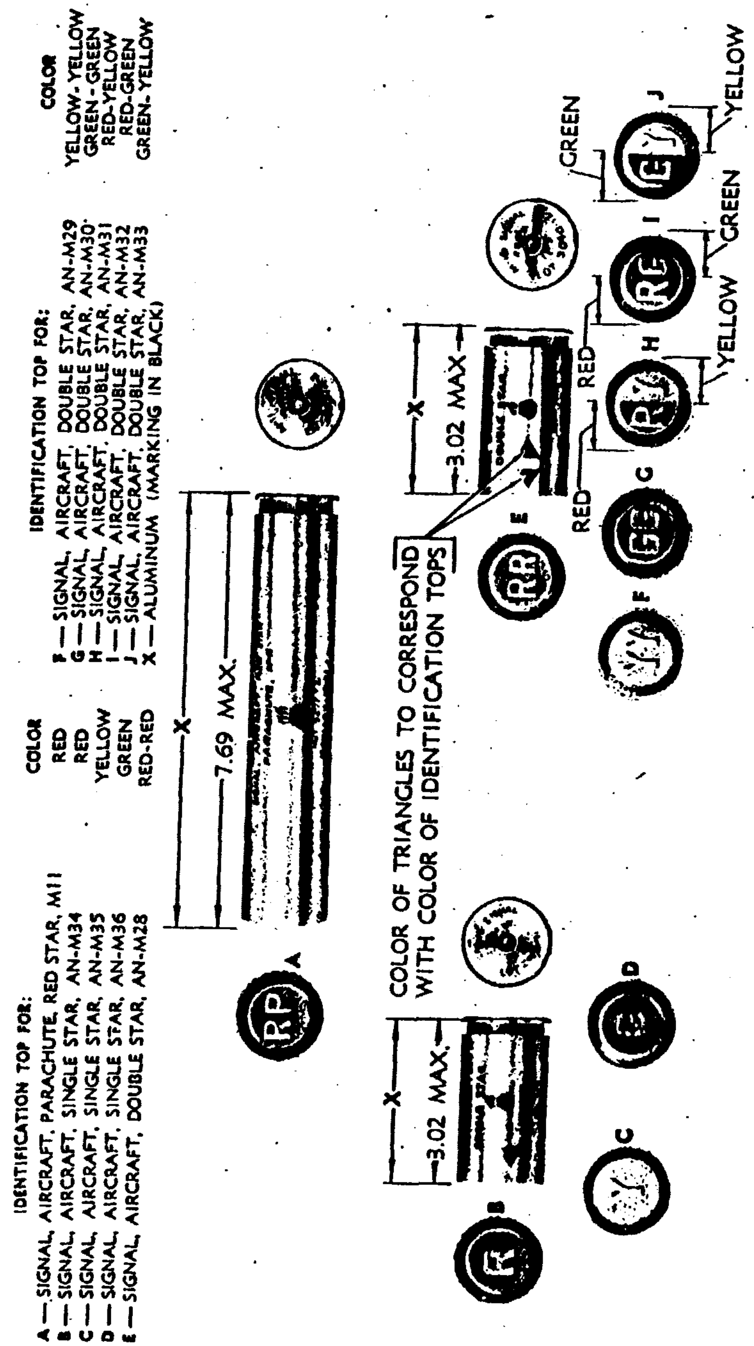


Figure 285 — Aircraft Signals

5. SIGNAL, aircraft, double star, Red-green, AN-M32.
6. SIGNAL, aircraft, double star, Green-yellow, AN-M33.
7. SIGNAL, aircraft, single star, Red, AN-M34.
8. SIGNAL, aircraft, single star, Yellow, AN-M35.
9. SIGNAL, aircraft, single star, Green, AN-M36.

These signals consisted of a star composition loaded in an aluminum cup and contained within an aluminum barrel, with dimensions of 3.02 by 1.56 inches. They were designed to be fired from the M2 Pyrotechnic Pistol. Each star composition burned for 7 seconds, with the candlepower depending upon the color of the star.

In April 1942, the "Interim" type signals were declared limited standard, and the "Final" type series signals were standardized to replace the "Interim" type.

The "Final" type signals closely resemble the British aircraft signals.

These signals are assembled in a shotgun type shell of cartridge paper with a brass head. The signal cartridge is 3.85 inches in length by 1.537 inches in diameter. They are designed for use in the breech loading PISTOL, pyrotechnic, AN-M8. Upon firing, the propelling charge ignites and projects either one or two freely falling stars, which burn from 7 to 13 seconds. The candlepower depends upon the color of the star.

Included in the "Final" type series are also six double star and three single star signals.

1. SIGNAL, aircraft, double star, Red-red, AN-M37.
2. SIGNAL, aircraft, double star, Yellow-yellow, AN-M38.
3. SIGNAL, aircraft, double star, Green-green, AN-M39.
4. SIGNAL, aircraft, double star, Red-yellow, AN-M40.
5. SIGNAL, aircraft, double star, Red-green, AN-M41.
6. SIGNAL, aircraft, double star, Green-yellow, AN-M42.
7. SIGNAL, aircraft, single star, Red, AN-M43.
8. SIGNAL, aircraft, single star, Yellow, AN-M44.
9. SIGNAL, aircraft, single star, Green, AN-M45.

Color Identification.

Original type. The color of the star is shown on the closing or identification top of the outer case. In the one signal that is now standard, the top is painted red to illustrate the color of the star, and the top is also embossed with the letters "RP" to make identification possible at night. "R" signifies red, and "P" signifies parachute.

Interim type. In the "Interim" type of signal, the closing top is painted the same as in the original type. For the single stars, the top is a solid color of the same color as the star, and is embossed with a letter also corresponding to the color. In the double stars, the

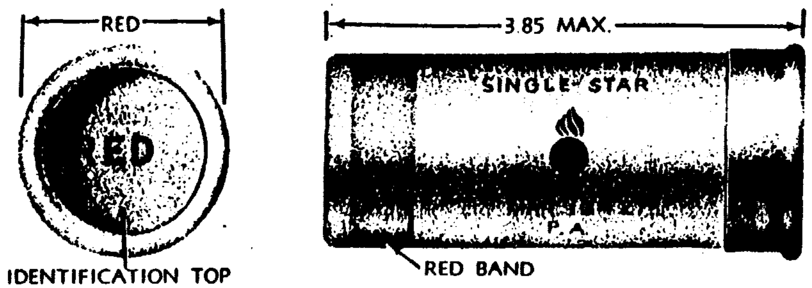


Figure 286 — SIGNAL, Aircraft, Single Star, AN-M43

top is painted to represent the color of the stars with each half taking the color of one of the stars; in addition, the letters which correspond to the colors are embossed in their proper colors.

In addition to the marking of the closing top, the barrel itself is marked with colored bands to represent the color of the star. In the single star signals, one band is used and is ½ inch wide. In the double star signals, two bands are used, each being ¼ inch wide and ¼ inch apart. Each band is the color of the star it represents.

Final type. The "Final" type of signals is marked at the top in the same manner as the "Interim" type except that the word of the color is spelled out and is printed instead of being embossed. The barrels are marked in the same manner as the "Interim" type signals.

By means of these identification features it is possible to determine the type and color of the signal, even should the standard stenciling and nomenclature be obliterated.

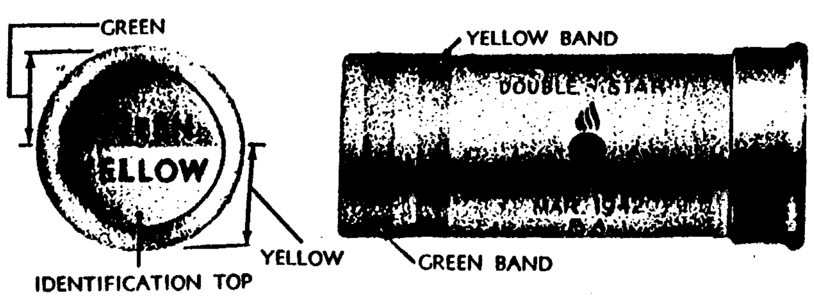


Figure 287 — SIGNAL, Aircraft, Double Star, AN-M42

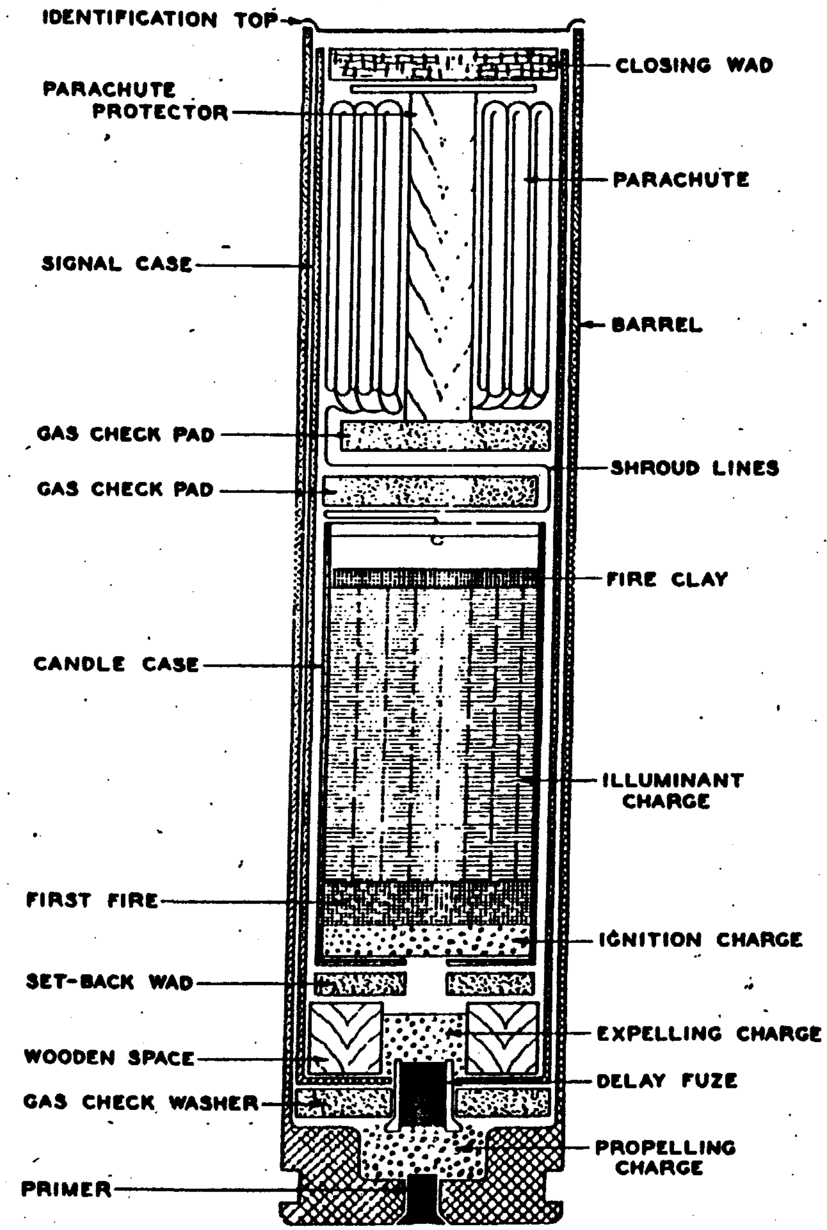


Figure 288 — SIGNAL, Aircraft, Red Star, Parachute, M11

SIGNAL, AIRCRAFT, RED STAR, PARACHUTE, M11.

Use. For signaling from aircraft to other aircraft, or from aircraft to ground units. Also used as a distress signal when fired from a grounded plane.

Description. Length = 8 inches; diameter = 1½ inches; weight = 9½ ounces; burning time = 30 seconds; candlepower = 30,000.

Construction. This signal is constructed with an outer case of aluminum, known as the barrel, which is closed at one end with a metallic closing cap. At the other end, which is permanently closed in manufacture, is a percussion primer. Also around the base is an annular groove which serves to lock the signal in the projector. Inside the barrel is a black powder propelling charge which is held in a recess in the base and in contact with the primer.

Within the barrel is the signal case which is also constructed of aluminum. At the base of the signal case is the exposed end of the fuse train and a gas-check washer. Inside the signal case, at the base, is a wood spacer enclosing the inner end of the fuse train and holding an expelling charge of black powder. Above the wood spacer is a set-back wad of black felt upon which the candle case rests. Directly on top of the candle case are a pair of felt gas check pads, and a parachute of either cloth or paper. This parachute is held around a wood spacer known as the parachute protector. The signal case is closed with a cork closing wad.

The candle case is of paper with the lower end open in the center to expose the ignition charge. Following the ignition charge is a first fire charge, and finally the signal composition itself. Above the signal composition is a fire clay seal which protects the shrouds from being ignited.

Operation. The signal is locked in the projector and the trigger is squeezed causing the firing pin to strike the percussion primer. The flame from the primer ignites the propelling charge of black powder which propels the signal case into the air and ignites the exposed end of the delay fuse. This fuse burns for 2½ seconds and then ignites the expelling charge. The gas-check washer at the base of the signal case prevents the escape of the gases around the signal case and thus insures the maximum efficiency of the propelling charge.

When the fuse ignites the expelling charge, the candle and parachute are expelled into the air, and the exposed ignition charge is ignited. The set-back wad between the wood spacer and the candle serves to prevent the candle from being crushed due to the force of set-back. The gas-check pads between the candle case and the parachute serve to prevent the escape of gases past the candle, protect the parachute from fire, and cushion the upward thrust on the parachute and the wooden parachute protector. The wooden parachute

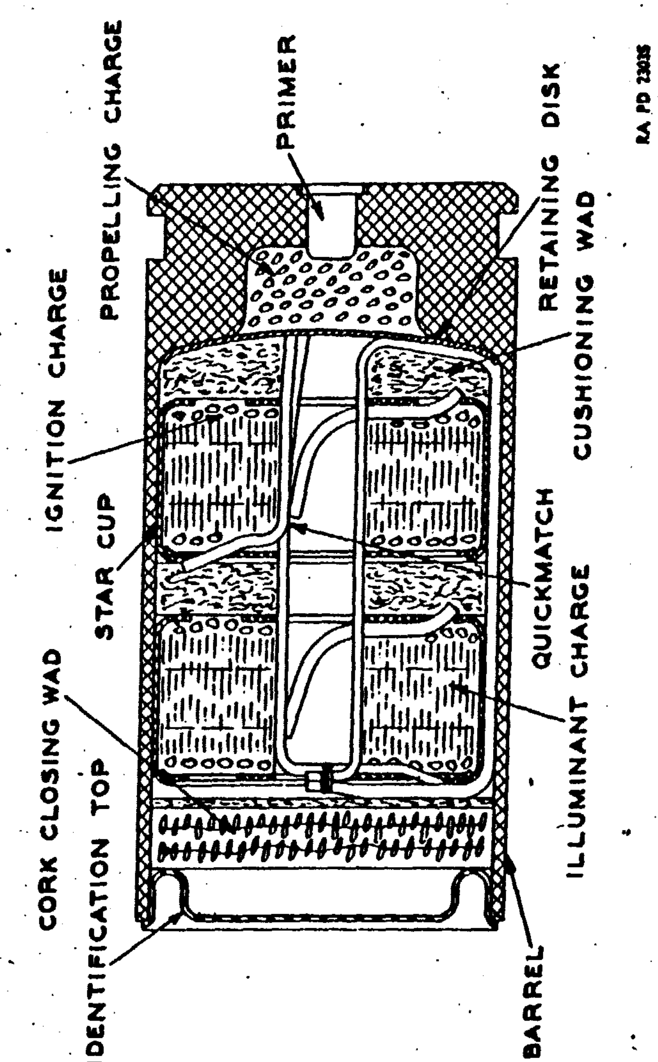


Figure 289 — SIGNAL, Aircraft, Double Star ("Interim" Type)

protector pushes out the cork closing wad, and the parachute and candle follow.

With the ignition of the ignition charge which in turn ignites the first fire charge, the burning train is initiated. The first fire charge insures the ignition of the signal composition which burns for approximately 30 seconds with a candlepower of 30,000.

SIGNAL, AIRCRAFT, DOUBLE STAR, AN-M28 to AN-M33 ("INTERIM" TYPE).

Use. For signaling from aircraft to other aircraft or to ground units.

Description. Length = 3.02 inches; diameter = 1.56 inches; weight = 5 ounces; burning time = 7 seconds.

Construction. There are six of the signals, aircraft, double star, of the so-called "Interim" type. They are similar to each other, varying only in the color and candlepower of the stars. The assembly consists of a pair of stars housed in an aluminum barrel, tied together with a length of quickmatch, and separated from each other by a cushioning wad. The aluminum barrel is grooved at the base to fit in the M2 Pyrotechnic Pistol, and contains in its base a primer and a propelling charge of black powder. This is held in place by an onionskin retaining disc.

Each of the stars consists of an aluminum cup filled with illuminant charge which is coated, top and bottom, with a layer of black powder ignition charge. The top and bottoms of the star cups are perforated with six holes, in addition to the large central hole running entirely through the stars. Through these holes are threaded lengths of quickmatch which run from the ignition charge on the face of each star to the top of the propelling charge. The stars are held in the barrel by the cork closing wad and the identification top. This identification top is made from thin sheet metal and has two letters embossed into it which describe the color of the stars; it is painted correspondingly.

Operation. The signal is locked in the pyrotechnic pistol and the trigger is squeezed, causing the firing pin to hit the primer. The flame from the primer ignites the propelling charge, which ignites the quickmatch and propels the stars from the barrel. The quickmatch, in turn, ignites the ignition charges on the tops and bottoms of the stars, and these in turn cause the signal composition to become fully ignited.

The flaming stars fly through the air, burning for about 7 seconds each.

SIGNAL, AIRCRAFT, SINGLE STAR, AN-M34 TO AN-M36 ("INTERIM" TYPE).

Use. For signaling.

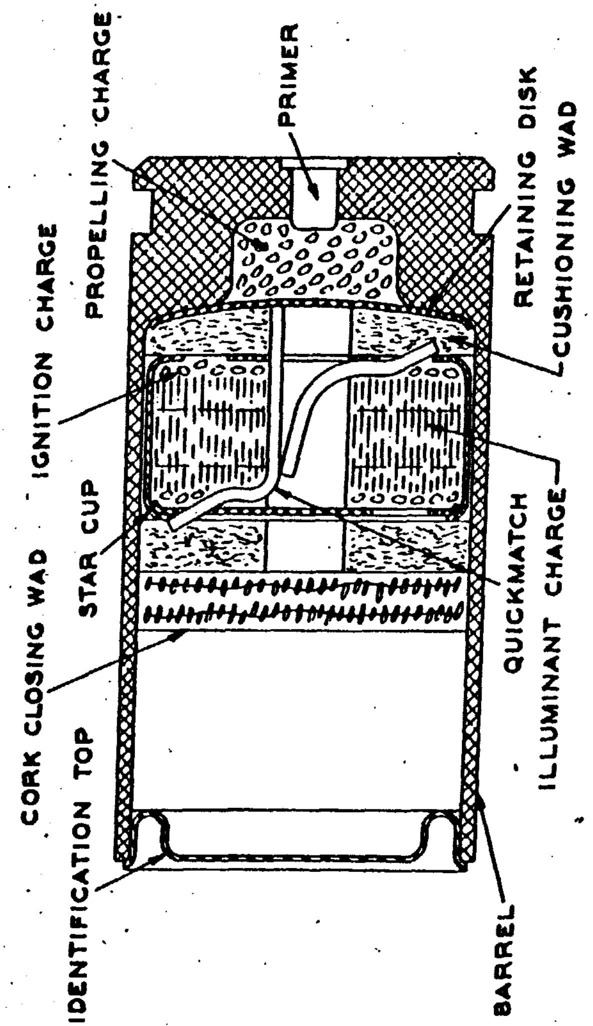


Figure 290 — SIGNAL, *Aircraft, Single Star ("Interim" Type)*

Description. Length = 3.02 inches; diameter = 1.56 inches; weight = 5 ounces; burning time = 7 seconds.

Construction. There are three of the signals, aircraft, single star of the so-called "Interim" type. They are similar to each other, varying only in the color and candlepower of the star. The assembly consists of a star housed in an aluminum barrel, protected by cushioning wads, and held in place by the cork closing wad. The star consists of an aluminum cup filled with illuminant charge which is coated, top and bottom, with black powder ignition charge. The top and bottom of the star cup are perforated with six holes in addition to the large central hole running entirely through the star. Through these holes are threaded lengths of quickmatch running from the ignition charge on the face of the star to the top of the propelling charge. The propelling charge consists of black powder and is housed in the barrel underneath the onionskin retaining disc in contact with the primer. The top of the barrel is closed with an identification top which is painted the same color as the signal, and which has a corresponding letter embossed in it.

Operation. The signal is locked in the pyrotechnic pistol and the trigger is squeezed, causing the firing pin to hit the primer. The flame from the primer ignites the propelling charge, which ignites the quickmatch and propels the star from the barrel. The quickmatch, in turn, ignites the ignition charges on the top and bottom of the star, and these in turn cause the signal composition to become fully ignited.

The flaming star flies through the air, burning for about 7 seconds with the candlepower depending upon the color of the star.

SIGNAL, AIRCRAFT, DOUBLE STAR, AN-M37 TO AN-M42 ("FINAL" TYPE).

Use. For signaling.

Description. Length = 3.85 inches; diameter = 1.537 inches; weight = 6.4 ounces; burning time = 7-13 seconds.

Construction. There are six of the signals, aircraft, double star, of the "Final" type. They are similar to each other, varying only in the color and candlepower of the stars. The assembly consists of two stars housed in a cardboard signal case, protected by cushioning wads, and tied together with quickmatch. Each star consists of an aluminum cup filled with illuminating charge which is coated, top and bottom, with black powder ignition charge. The top and bottom of each star cup are perforated with six holes, in addition to the large hole running entirely through the center of the stars; through these holes are threaded lengths of quickmatch running from the ignition charge on the faces of the stars to the top of the propelling

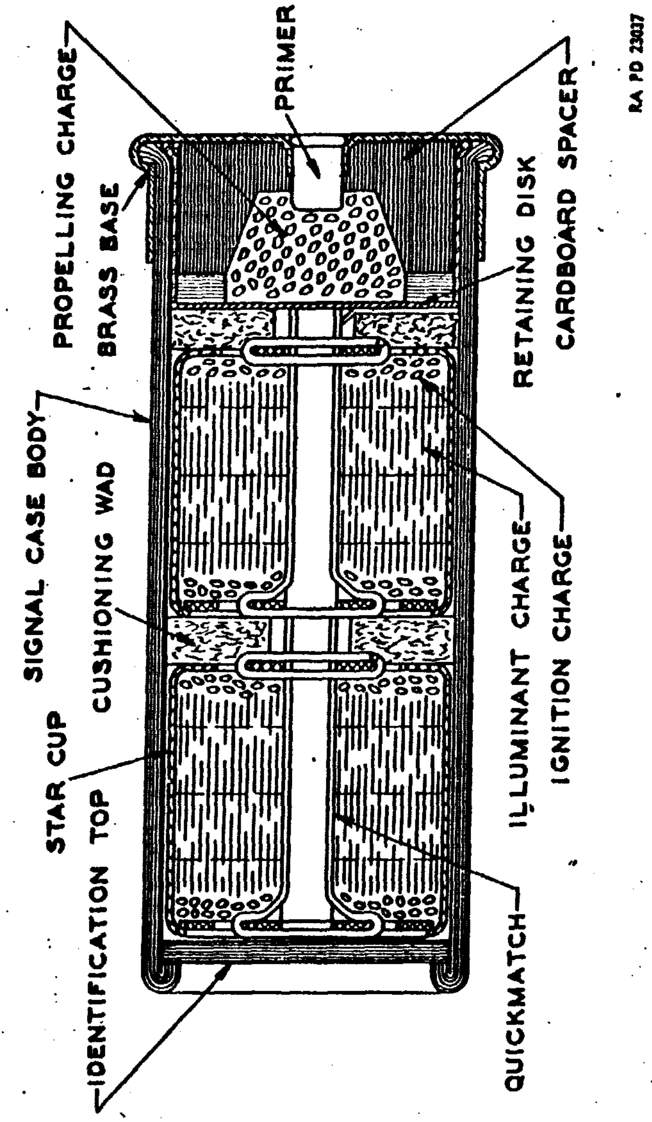


Figure 291 — SIGNAL, Aircraft, Double Star ("Final" Type)

charge. The propelling charge consists of black powder and is housed in a cardboard spacer inside the signal case underneath an onionskin retaining disc, and is in contact with the primer. The bottom of the signal case is reinforced by a thin brass base which provides a rim for seating the signal in a projector.

The top of the signal case is closed by a 360-degree, crimp-fastened, cardboard identification top which is colored correspondingly to the color of the signal.

Operation. The signal is inserted into the breech of the pyrotechnic pistol, and the trigger is squeezed, causing the firing pin to hit the primer. The flame from the primer ignites the propelling charge, which ignites the quickmatch and propels the stars from the signal case. The quickmatch, in turn, ignites the ignition charges on the tops and bottoms of the stars, and these cause the signal composition to become fully ignited.

The flaming stars fly through the air, burning for 7 to 13 seconds each, with the candlepower depending on the color of the star.

SIGNAL, AIRCRAFT, SINGLE STAR, AN-M43 TO AN-M45 ("FINAL" TYPE).

Use. For signaling from aircraft to other aircraft, or to ground units.

Description. Length = 3.85 inches; diameter = 1.537 inches; weight = 6.4 ounces; burning time = 7-13 seconds.

Construction. There are three of the signals, aircraft, single star of the "Final" type. They are similar to each other, varying only in the color and candlepower of the star. The assembly consists of a star housed in a cardboard signal case protected by cushioning wads, and held in place by a spacer and a spacer disc. The star consists of an aluminum cup filled with illuminant charge which is coated, top and bottom, with black powder ignition charge. The top and bottom of the star cup are perforated with six holes, in addition to the large central hole running entirely through the star; through these holes are threaded lengths of quickmatch running from the ignition charge on the face of the star to the top of the propelling charge. The propelling charge consists of black powder, and is housed in a cardboard spacer inside the signal case underneath an onionskin retaining disc, and is in contact with the primer. The bottom of the signal case is reinforced by a thin brass base which provides a rim for seating the signal in the projector. The top of the signal case is closed by a 360-degree, crimp-fastened cardboard identification top which is colored corresponding to the color of the signal.

Operation. The signal is inserted into the breech of the pyrotechnic pistol and the trigger is squeezed, causing the firing pin to

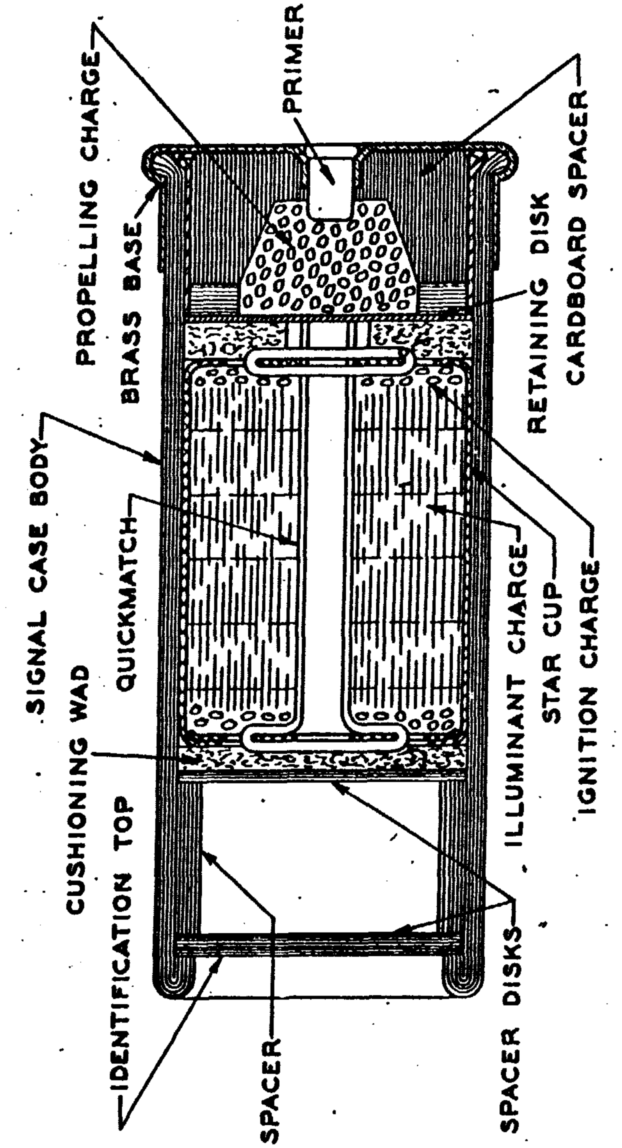


Figure 292 — SIGNAL, Aircraft, Single Star ("Final" Type)

strike the primer. The flame from the primer ignites the propelling charge which ignites the quickmatch, and propels the star from the signal case. The quickmatch, in turn, ignites the ignition charges on the top and bottom of the star, and these cause the signal composition to become fully ignited.

The flaming star flies through the air, burning for about 7 to 13 seconds, with the candlepower depending on the color of the star.

GROUND SIGNALS.

General. Ground signals are designed to be fired from the PROJECTOR, pyrotechnic, M1, M3, or M4. They are similar to the aircraft signals in construction, except that the signal case closing cap carries a tail and fin assembly to improve flight characteristics. The fin is marked by painting and embossing for identification purposes.

Operation is similar to that for the aircraft signals except that the signal case is projected from the fixed barrel of the projector instead of from an individual removable barrel as is the case with aircraft signals. The signal is fired by the impact of the signal primer with the firing pin of the projector. In the case of the PROJECTOR, pyrotechnic, M1, the firing pin is operated by a pull on the lanyard. In the case of the PROJECTOR, pyrotechnic, M3 or M4, the projector is struck smartly on the ground, thus driving the signal primer against a fixed firing pin.

SIGNAL, GROUND, WHITE STAR, PARACHUTE, M17.

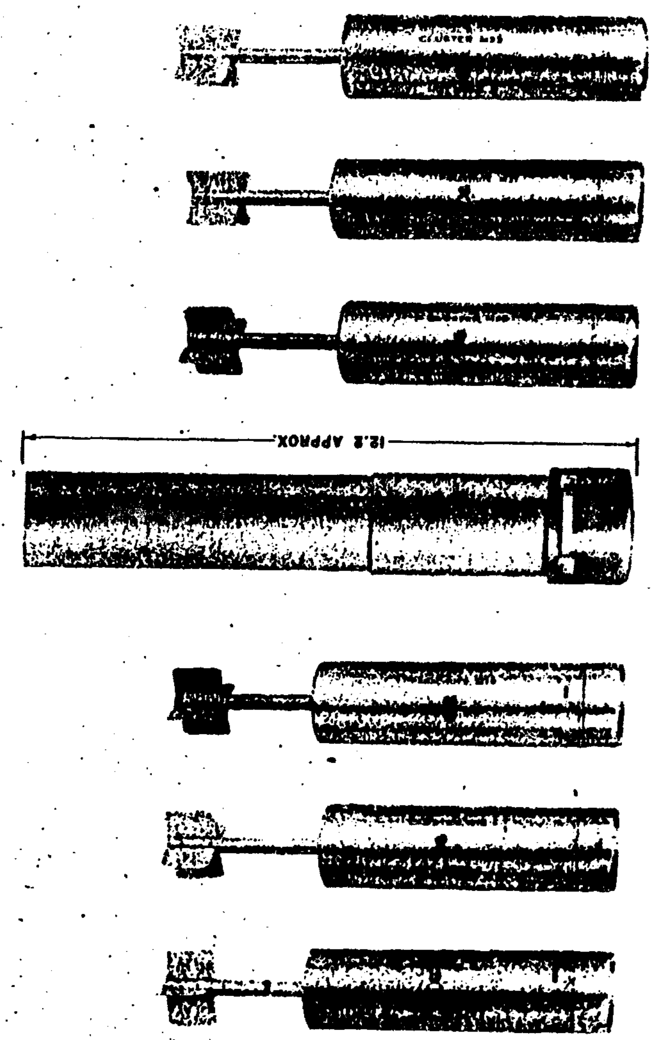
Use. For signaling from ground units to other ground troops, or to aircraft.

Description. Length = 9 inches; diameter = 1½ inches; candlepower = 20,000; burning time = 20 to 30 seconds.

Construction. The signal case is a drawn aluminum body closed at one end by a fuze housing which is attached by four crimps. This fuze housing is chambered to hold the propelling charge of Herco powder. A breech cap, which screws on the fuze housing, holds the propelling charge in place, and also provides a seat for the percussion primer.

The upper end of the fuze housing contains a circular time-train groove filled with black powder and covered with a fire clay seal except for the pellet of black powder which extends through the seal.

Inside the signal case, on the inner surface of the fuze housing, is an expelling charge of black powder connected to the fuze train by means of a flash hole in the fuze housing. This expelling charge is held in place by means of an onionskin retaining disc. Above the retaining disc is a set-back wad of black felt which is open in the center to allow the passage of the flame. Resting on the set-back wad



RA PD 4001

Figure 293 — Ground Signals and Projector

is the candle case which is covered by the gas-check washer of black felt. Over this may be found the parachute of cloth or paper; the wooden parachute protector around which the parachute is wound; the cardboard closing disc; and finally, the tail and fin assembly which closes the signal case.

The candle case itself is of cardboard, with the end nearest the expelling charge closed by means of an aluminum cap which is perforated. A strip of quickmatch is inserted into the cap. The ignition charge follows the quickmatch and is itself followed by the first fire charge and then the signal composition. Above the signal composition is a fire clay seal.

Operation. When the projector functions, the flame from the primer ignites the propelling charge which is held in the breech cap. The pressure of the propelling charge gases blows out the four recesses in the breech cap, and causes the signal case to move out of the projector. At the same time, the flame from the propelling charge ignites the black powder pellet of the time-train which ignites the time-train itself. The time-train burns in both directions giving a delay of 5½ seconds, then flashes the flame through the flash hole to the expelling charge. This delay allows the signal to reach a height of approximately 600 feet. When the expelling charge is ignited, the pressure of the gases forces the candle and parachute assembly from the signal case, and at the same time the flame ignites the strip of quickmatch. This ignites the ignition charge, then the first fire charge, and finally the signal composition.

The candle burns for approximately 20 to 30 seconds with a candlepower of 20,000 while suspended from the parachute.

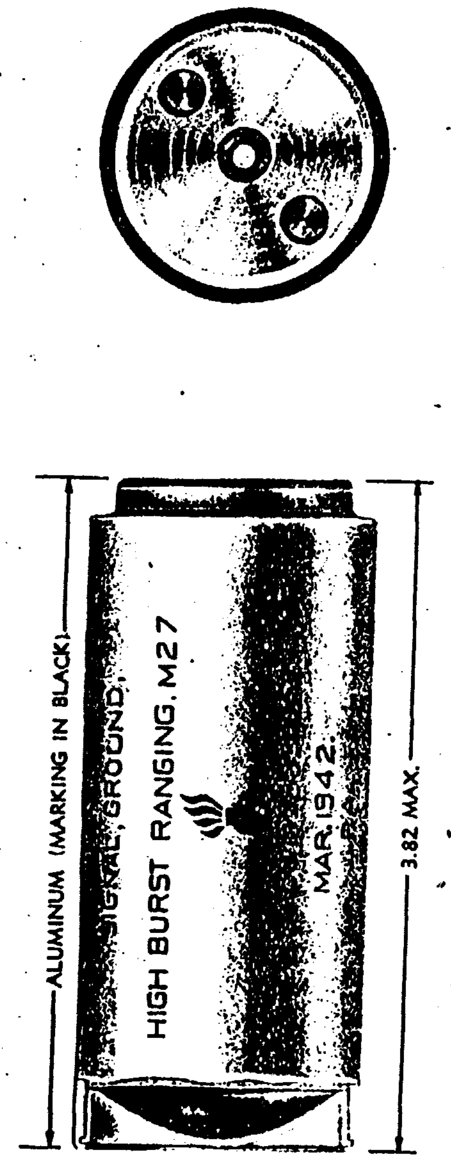
NOTE: At about 100 feet, the signal flips over so that the tail and fin assembly act to stabilize the flight for the remaining 500 feet.

Other Ground Star Signals. In addition to the White Star Parachute Signal M17, the following are at present also standard for issue and manufacture:

SIGNAL, ground, white star, cluster, M18.
SIGNAL, ground, green star, parachute, M19.
SIGNAL, ground, green star, cluster, M20.
SIGNAL, ground, amber star, parachute, M21.
SIGNAL, ground, amber star, cluster, M22.

The cluster type signals function in the same manner as the single star parachute type with the exception that there are five freely falling stars that make up the cluster. These are each held in an aluminum star cup similar to those studied in the aircraft signals, and tied together with quickmatch.

The candlepower and burning rate for each of the above signals varies with the color of the star.



RA PD 2122

Figure 294 — SIGNAL, Ground, High Burst Ranging

MISCELLANEOUS PYROTECHNICS.

SIGNAL, Ground, High Burst Ranging, M27. This type of signal produces a smoke puff at the top of its rise and is used to simulate the high burst of artillery shell. It is fired from the M1A1 Projector and rises to an altitude of approximately 550 feet.

Further information is not available for publication at this time.

SIGNAL, Drift, Day, AN-Mk. I. This signal consists of a streamlined clay shell containing a metallic powder. When the signal is dropped in water the shell breaks, allowing the metallic powder to form a slick on the surface, which may be used as a reference point for air navigation.

The shell is a waterproof clay, $\frac{1}{16}$ inch thick. The nose is of hemispherical shape, 3½ inches in diameter, and the body tapers over its 10-inch length to a blunt point. The cone of the tail has four clay fins formed integral with it, which tend to stabilize the flight of the signal. Because the clay shell is fragile, these signals should be handled with care to prevent their destruction.

SIGNAL, Drift, Night, AN-Mk. IV. This signal is torpedo-shaped and consists of a bronze hemispherical nose, a wood body tapered at the rear, and an aluminum alloy tail fin assembly. It is designed to float in water in a vertical position with the nose submerged. The wooden body is hollow and contains the first fire composition and the pyrotechnic pellet. The fuze functions when the signal strikes the water surface and ignites the first fire composition, which in turn ignites the pyrotechnic pellet. It burns out of the tail and projects a flame which may be used as a reference point for air navigation at night.

GRENADE, Hand, Smoke, HC, M8. While this round is discussed under its proper heading of grenades, it should be kept in mind that it has one use in the field of pyrotechnics in that it is issued to the Air Corps for use as an emergency distress signal.

HANDLING.

All pyrotechnics should be protected against moisture, continued high temperatures, and sudden fluctuations in temperature. If exposed to moisture they should be segregated until examination can be made to show if the pyrotechnic is still serviceable or if any dangerous conditions exist.

All pyrotechnics should be handled with care to prevent the possibility of functioning the friction igniters or of setting off the pyrotechnic compositions in cases such as the photoflash bomb. Care should also be exercised to prevent damage to the cases, especially in the instance of those fired from a projector, where a damaged

case might cause a round to become lodged in the bore of the projector.

It should be kept in mind at all times that photoflash powder is as hazardous as black powder.

STORAGE.

Pyrotechnics should be stored in a dry, well ventilated place, out of the direct rays of the sun, and should be protected against excessive or variable temperatures. Pyrotechnics should not be stored with other kinds of ammunition, except small-arms ammunition. When storage space is limited, pyrotechnics, except photoflash bombs, may be stored with burning type chemical ammunition (group D) provided the total quantity of pyrotechnic, chemical, and explosive material in the magazine does not exceed 1,000 pounds. Photoflash bombs may not be stored with other types of ammunition except under conditions of limited storage space when they may be stored in one magazine with small-arms ammunition, provided the total amount of explosives and flashlight powder does not exceed 1,000 pounds. Red and green light compositions may explode under certain conditions and hence should be stored separately if practical. Certain pyrotechnics deteriorate in storage and have an expiration date on the containers. Care should be taken to observe the directions for disposal of this material at the time indicated as prescribed in OFSB 3-9.

FIRE.

Pyrotechnics such as photoflash bombs and high burst ranging signals explode when heated, but most types burn with an intense heat and without serious explosions. Water should not be used to combat fires involving material containing magnesium.

FURTHER REFERENCES: OS 9-18, Volume 3; TM 9-1981; OFSB 3-9; SNL S-5; O.O. No. 7224; Ordnance Sergeant, September 1942 and December 1942.

AMMUNITION INSPECTION GUIDE

SECTION IX.

DESTRUCTION OF UNUSABLE AMMUNITION AND EXPLOSIVES

chapter 1 Superseded by TM 9-1905, 24 Sep 48.

Chapter 1
Introduction

UNUSABLE AMMUNITION.

The term "unusable" has replaced the term "unserviceable" with regard to destruction because it gives a better understanding of what materials are destroyed. Unserviceable ammunition and explosives are those that are in such a condition as to render them unfit for their intended purposes. Unusable components include those that are unfit for their intended purposes and cannot be used to advantage for any other purpose. Unusable ammunition or explosives may include the following:

Items of faulty manufacture. Materials which have failed to pass inspection.

Deteriorated materials. Deterioration has rendered them unsafe or ineffective.

Damaged components. Ammunition damaged beyond repair during manufacture, shipment or storage.

Obsolescent materials. Outdated ammunition or explosives which have been replaced by newer materials and which are made ineffective or detrimental by changes in methods of warfare.

Captured materials. The conversion of some captured ammunition for use by friendly troops is considered unfeasible.

Duds. Ammunition that has been properly initiated and has failed to function, but may function at any time.

SALVAGE.

Only ammunition or explosives that cannot be economically salvaged are destroyed. Salvage is a reclaiming rather than a destruction operation. For this reason, salvage operations will not be included in this chapter. It should also be recognized that during times of war certain materials, particularly metals, take on such strategic value as to become priceless. Under wartime conditions, cost would not be considered in the salvaging of such materials.

SAFETY.

The dangerous nature of explosives makes safety the major consideration in their destruction. They are made immeasurably more dangerous by deterioration because the sensitivity of such explosives

is usually increased. Safety must not be sacrificed for cost reduction and speed. There are cases on record of explosions which destroyed property worth much more from the standpoint of dollars and cents and the time necessary for replacement than could be saved through several years of relaxation of certain fundamental safety rules. This is to say nothing of lives that were lost and could not be replaced. Investigations of such explosions almost invariably bring out evidence indicating negligence or disregard of some safety precaution.

Every person engaged in an explosive operation should feel that it is his or her duty to see that pertinent safety regulations are enforced. There is a tendency among personnel to become less respectful of explosives upon observing that rough handling does not always result in an explosion. It should be remembered that explosives are fickle and when treated in certain disrespectful ways will respond violently. This fact, along with safety rules applicable to the item and operation, should always be pointed out to persons caught handling explosives carelessly.

The Ordnance Safety Manual and TM 9-1900 contain regulations for the safe handling of the various classes and types of ammunition and explosives. These rules, where applicable, will be observed in addition to the specific safety regulations presented in this chapter.

RESPONSIBILITY AND PROCEDURE.

General. Usually the ammunition inspector is given the responsiability for the disposition and actual destruction of unserviceable ammunition and explosives at ordnance establishments. Whenever ammunition or explosives are discovered to be unserviceable, the ammunition inspector will prepare and submit an Ammunition Condition Report (O.O. Form 7235) to the Office of Chief of Ordnance.

The Ammunition Condition Report (A.C.R.). This will include the following in the order given:

1. The number of the station the report is sent from in the block in upper left-hand corner.

2. The number assigned to the report for filing purposes in the block in the upper right-hand corner.

3. Complete standard nomenclature of the item in question.

4. The lot number assigned to the item.

5. The name of the station.

6. The date the report is written.

7. The quantity of components in the lot.

8. The number of components inspected.

9. The number of components found to be unserviceable.

10. A brief, concise, yet complete explanation of the reason or rea-

AMMUNITION CONDITION REPORT

Station No. 465

O. O. No. 10460

Item Shell, semi-fixed, gas, persistent, HS, M64, w/FUZE, P.D., M57, 75-mm how., M1 & M1A1 Lot No. E.A. 475-16

Station Delaware Ordnance Depot Date 5-16-42 Quantity in lot 5000

Number inspected 5000 Number found unserviceable 3

The unserviceability of the items covered by this report was not due to fault or neglect.

Reasons for unserviceability:

Three (3) rounds leaking slightly at nose from burster well casing. Recommend immediate local destruction.

Signature of Commanding Officer
(Signature)

FIRST ENDORSEMENT

Ordnance Office, ________ Date ________

(Signature)

SAMPLE

SECOND ENDORSEMENT

War Department, Ordnance Office. Date 5-20-42

Recommendation approved.

Signature of Ordnance Officer.
Ordnance Department, Assistant.

THIRD ENDORSEMENT

Delaware Ordnance Depot Date 5-25-42

1. It is advised that the above-authorized work has been completed, in accordance with the second indorsement.

Signature of Commanding Officer
(Signature)

O. O. Form 7 [illegible]
Revised [illegible]

(SAMPLE)

RA PD 23038

Figure 295 — Condition Report—Obverse

INSTRUCTIONS

1. This form will be used for unserviceable ammunition, components, and explosives. Ammunition, components, and explosives will be considered unserviceable when they cannot be safely and effectively used for their intended purpose.

2. When ammunition becomes unserviceable by reason of fault or neglect, the statement to the contrary on reverse side will be lined out, and this report will be accompanied by a report of survey fixing responsibility.

3. Prepare a separate report for each lot involved, and forward in quadruplicate to the Chief of Ordnance, except that where the defects are common to several lots, a single Ammunition Condition Report will be used, enumerating by lot number the quantities involved. No letter of transmittal is required.

4. All information must be definite and complete, but as brief as possible. Do not list correspondence reference numbers in lieu of full information; but make sure that this report tells the whole story. Do not state that an item is "unserviceable" without adding why and to what extent. Quote test results when available. Modify descriptions of condition by indications of degree, such as "slight rust," "very heavy corrosion," "extreme exudation," etc.

5. Each report will be signed by or for the Commanding Officer or the station Ordnance Officer, and forwarded through the corps area or department Ordnance Officer, where applicable, for his recommendation.

6. Renovation plants will NOT use this form to report unserviceable ammunition or components resulting from renovation operations.

7. Instructions for disposition will be endorsed on the original report, which will be returned for the permanent files of the station. The Chief of Ordnance will be informed of completion of the authorized work by third endorsement on one copy of the report, thus closing the case.

8. When endorsement to this report orders the transfer of ammunition or ammunition components, two certified copies will be forwarded to the consignee with the shipping ticket.

9. See Section II, Circular No. 80, dated October 12, 1939, for use of this form as a property voucher.

U. S. GOVERNMENT PRINTING OFFICE 10—[illegible]

THIS SPACE FOR CONTINUATION OF DESCRIPTION OF DEFECTS, AND FOR ORDNANCE OFFICE NOTES OR INSTRUCTIONS

RA PD 23039

Figure 296 — Condition Report—Reverse

sons for unserviceability.

11. Disposition may or may not be recommended. Such recommendation will facilitate the second indorsement, however. If recommendation for disposal is not made, the Office of the Chief of Ordnance will state the disposition and method in the second indorsement.

A sample of a completed Ammunition Condition Report is illustrated in figures 295 and 296. The person preparing the report should be sure to read the instructions shown on reverse.

When the basic A.C.R. is prepared as outlined above, it is sent to the Commanding Officer for his signature. It is then forwarded in quadruplicate to the Renovation and Surveillance Section, Office Chief of Ordnance. As many more copies as are required at the establishment will be made. The representative of the Chief of Ordnance will either state how the material is to be disposed of or will approve the ammunition inspector's recommendation for disposal by second indorsement. The first indorsement is used only in the case of Ports of Embarkation or Service Commands. After the second indorsement is made, the report is returned to the station and the material is disposed of as directed. The case is then closed by third indorsement stating that the work has been completed in accordance with the second indorsement and the form is returned to the Chief of Ordnance.

The only exception to this procedure is in the case of ammunition or explosives that are considered immediately dangerous to life and property. When this is true, the destruction may be authorized by the Commanding Officer of the establishment. The A.C.R. is then made out and the Office, Chief of Ordnance is advised in the basic report that the destruction has been completed.

METHODS OF DESTRUCTION.

Three general methods are authorized for the destruction of ammunition and explosives: detonation, also referred to as demolition or static firing; burning; and dumping at sea, establishments located near coasts may dump at sea. Burying or dumping into waste places, pits, wells, marshes, shallow streams or inland water ways is prohibited except as may be authorized under provisions of paragraphs 66a and 259d of the Ordnance Safety Manual for the disposition of black powder and chemical ammunition.

Chapter 2

Destruction by Detonation

GENERAL.

Ammunition components may be destroyed by initiating the explosive contained or by the force of explosion of explosive materials

placed in contact with the item. Components destroyed in such a manner are as follows:

Artillery projectiles
Aircraft bombs
Trench mortar shell
Antitank mines
Rockets
Offensive hand grenades
Rifle grenades
Fuzes, primers, detonators, boosters, and bursters
Photoflash bombs
Duds

One of two firing systems may be used to detonate the above items: the electric or the nonelectric systems.

THE NONELECTRIC FIRING SYSTEM.

The nonelectric firing system consists of a high explosive, a nonelectric blasting cap inserted into the explosive, and a length of miners' safety fuse inserted into the cap.

High Explosives. Detonation of ammunition components at ordnance establishments is accomplished with one of three explosives, TNT, nitrostarch, or dynamite. A fourth explosive, composition C, has been developed but information concerning it is not available at this time. However, it is of a plastic nature and may be molded to any shape.

Explosive, TNT, rectangular. TNT is issued in rectangular blocks, sometimes called "Triton" blocks, for destruction work. The blocks, as issued, weigh ½ pound and are 1¾ inches square by 3¼ inches long. Each block is incased in a cardboard container closed at both ends with lacquered tin. At one end is a cylindrical hole approximately 2⅛ inches deep to receive a blasting cap. This hole is covered with tissue paper. The blasting cap must not be forced through this paper; the paper should first be broken with a sharp piece of wood or similar instrument.

TNT blocks are "Standard" for destruction work because TNT most nearly fulfills the requirements of an ideal explosive for the task. It is comparatively insensitive in all forms. This characteristic makes a powerful detonating agent necessary. Fulminate of mercury will not positively detonate TNT so commercial blasting caps cannot be depended upon for its detonation. It may be positively detonated by special issue tetryl caps or detonating cord. TNT is insoluble in water and may be used for demolition work under water. A disadvantage is that explosion of TNT produces poisonous gases. However, these gases are so rapidly dissipated in open air that they are ren-

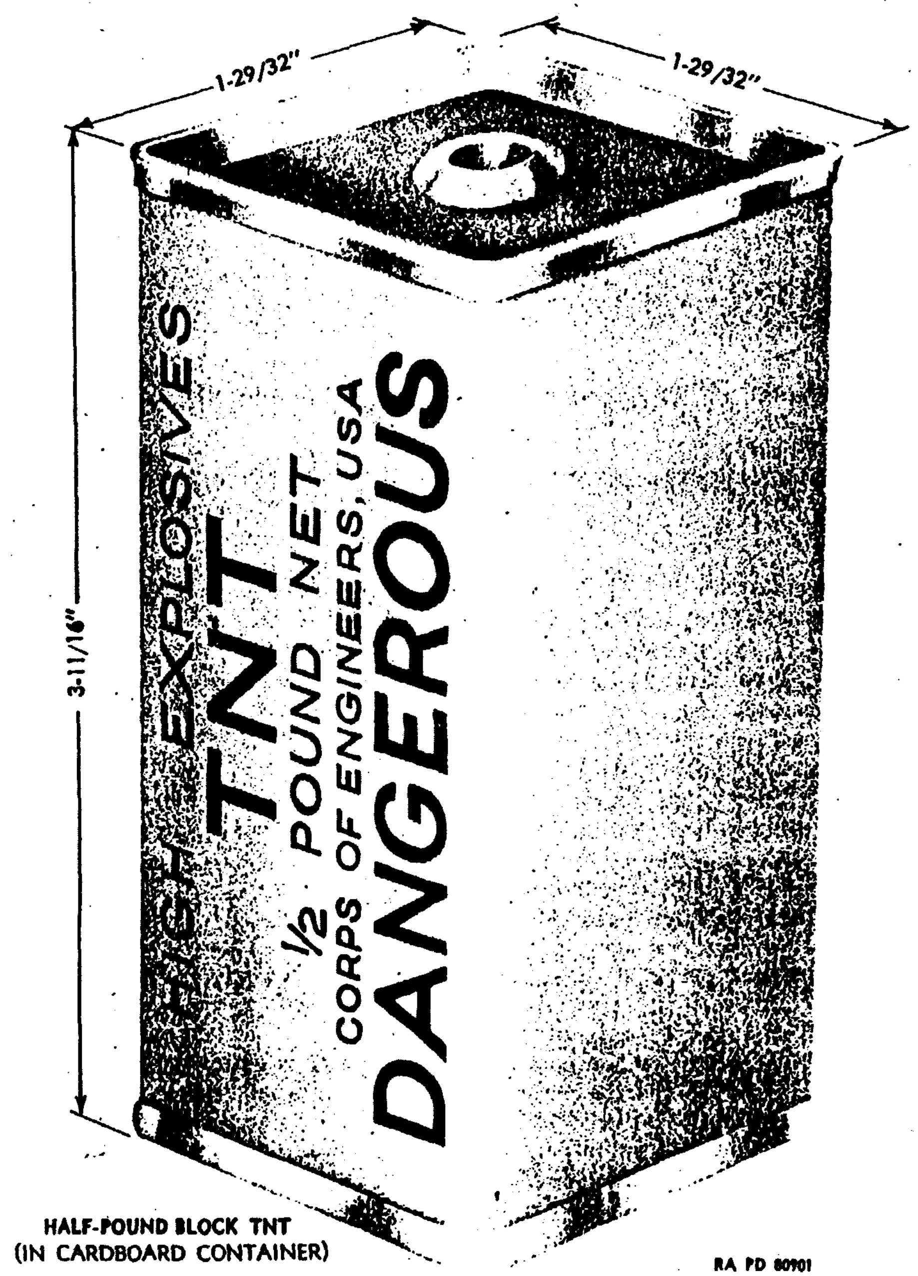


Figure 297 — Triton Block

dered harmless. The production of poisonous gases does prohibit the use of TNT in situations where the gases are confined.

Explosive, nitrostarch, rectangular. Nitrostarch is a substitute for TNT for destruction work. It is issued either in ½-pound blocks, 1.906 inches square by 3.062 inches long with a cap hole as in the TNT block; and in ¼-pound blocks, 1¼ inches square by 2½ inches long with a cap hole extending all the way through the length of the block. These blocks are wrapped in paraffin-treated paper. For convenience of handling and use, ¼-pound blocks are assembled into pound packages.

For practical purposes, the same methods and computations as for TNT are applicable. However, nitrostarch is somewhat more sensitive to friction, impact and flame or spark than TNT and consequently more care must be exercised in its use. The ¼-pound and ½-pound blocks *must not* be broken into smaller pieces.

Dynamite. Commercial straight dynamite consists of nitroglycerin absorbed in some porous material such as sawdust. The percent of the dynamite signifies the actual percent of nitroglycerin by weight. It is issued for destruction work in two types: dynamite, 40 percent (commercial) and dynamite, 50 to 60 percent (commercial). The 40 percent is issued on the basis of 1¼ pounds for each pound of TNT. The 50 to 60 percent is issued on an equal weight basis with TNT. Dynamite is usually packed in approximately ½-pound cartridges 1¼ inches in diameter by 8 inches long, of water-resistant-treated paper.

Dynamite is more sensitive than other high explosives and must be handled accordingly. Cases of dynamite should be stored right side up so that the cartridge will lie flat and will not stand on end. The cases should be turned every 30 days. The nitroglycerin has a tendency to shift to the under side and become concentrated and consequently much more dangerous.

Nonelectric Blasting Caps. Detonation of explosives such as TNT, nitrostarch, and dynamite is initiated by a small quantity of a more sensitive explosive contained in a cap. A No. 8 commercial blasting cap will detonate nitrostarch and dynamite. Special tetryl nonelectric or tetryl electric caps are necessary to insure detonation of TNT. Commercial blasting caps are numbered consecutively from 1 to 10, according to their strength, and contain, respectively, 0.3, 0.4, 0.54, 0.65, 0.80, 1.0, 1.5, 2.0, 2.5, and 3 grains of a mixture of 85 percent fulminate of mercury and 15 percent potassium chlorate. The special tetryl cap differs from the commercial cap in that its main charge is tetryl and is detonated by a small charge of fulminate of mercury and potassium chlorate.

The explosive charge of the cap is contained in a thin copper shell which is closed at the open end with a plug. The shell protrudes past the plug for assembly to miners' safety fuse by crimping.

AMMUNITION INSPECTION GUIDE

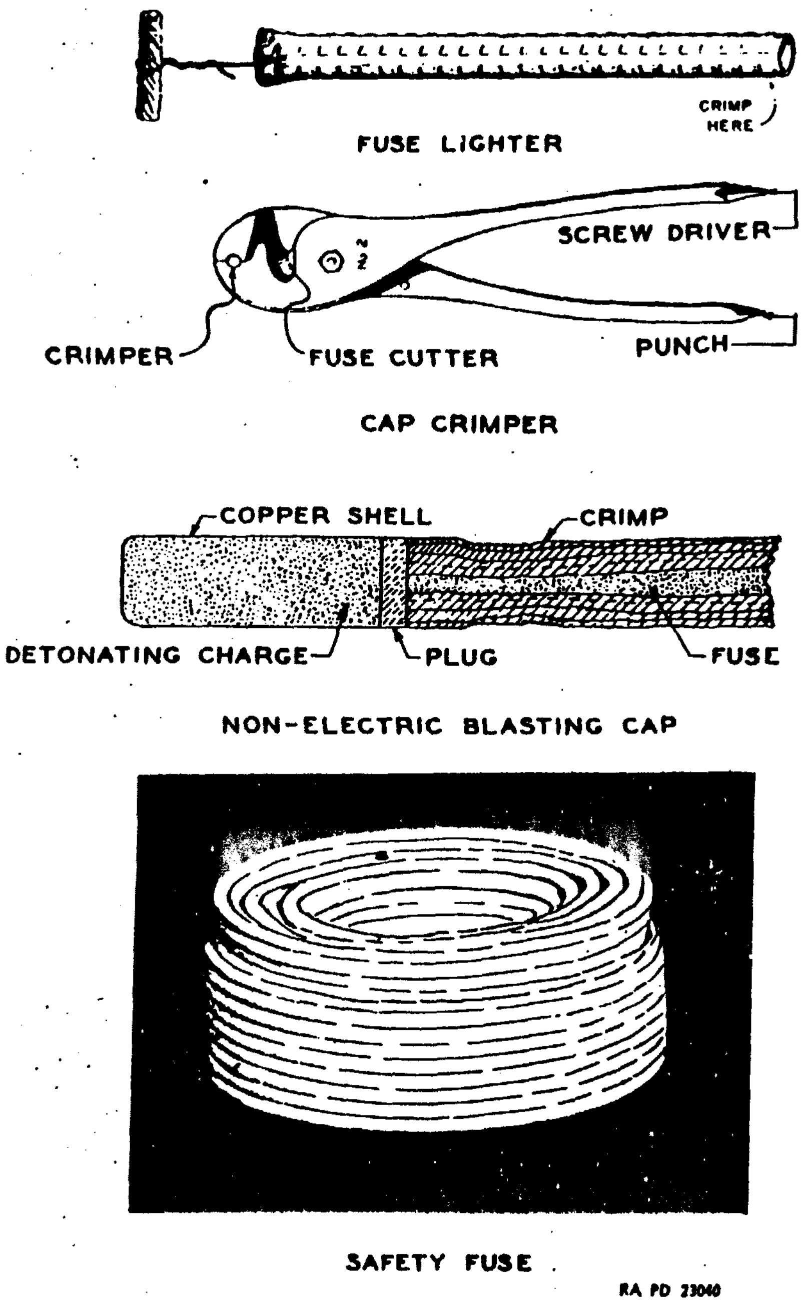


Figure 298 — Nonelectric Blasting Equipment

DESTRUCTION OF UNUSABLE AMMUNITION AND EXPLOSIVES

Safety precautions. The following safety precautions must be observed in the use of nonelectric blasting caps:

1. One person should be designated for the responsibility of taking care of the blasting caps during operations of destroying explosive components.

2. Blasting caps must not be stored or transported with high explosives.

3. Caps should not be left exposed to the direct rays of the sun.

4. Caps should not be carried in the pocket; there are special boxes made for the purpose.

5. Do not remove blasting caps from the box with a wire, a nail or similar instrument; use the fingers.

6. Do not use a weak cap. Use the prescribed cap or a more powerful one.

7. The cap should be held with the fingers by the open end. Subjecting the explosive to the heat of the hand should be avoided as much as possible. Heat increases the sensitivity of explosives.

8. Do not tap caps or attempt to disassemble them.

9. Do not hold the blasting cap in the hand while crimping. Place the cap on the fuse and holding the fuse in one hand crimp with the other. Hold the cap to one side, away from in front of the body while crimping. The crimp should be made at the extreme open end, opposite the explosive.

10. Do not crimp a cap with the teeth or a knife. Use the cap crimper.

11. Improvised methods of detonating blasting caps are prohibited.

Fuse, Blasting Time. This fuse is commonly called miners' safety fuse. It consists of a thin train of black powder tightly compressed and partially waterproofed in inner and outer wrappings. Safety fuse is manufactured in lengths of 50 feet and made into rolls. The exterior surface of the fuse is relatively smooth and is white or orange in color. These outward appearances cannot be depended upon for positive identification, however. The purpose of the fuse is to provide heat through the burning of the black powder to initiate nonelectric blasting caps and to provide enough time between the lighting of the fuse and the detonation of the cap to allow personnel to take cover. It burns at the rate of about 32 to 40 seconds per foot.

Safety precautions. The following precautions must be observed in the use and care of safety fuse:

1. The fuse should be stored in a cool, dry place free from oils, paints, gasoline, kerosene, distillates, and similar solvents that have a deteriorating effect on the fuse.

2. Care should be taken in handling not to twist the fuse or produce kinks, especially in cold weather. Such treatment will loosen the black powder and decrease the burning time.

3. Five or 6 inches should be cut from the end of the roll and discarded before using. The powder in the end is likely to have become damp or loose.

4. After 5 or 6 inches have been discarded, one foot must be cut from the roll and tested for burning time.

5. A length of fuse must be used that will give the person lighting it plenty of time to reach cover.

6. The fuse must square-cut. If an obliquely cut fuse is inserted into a blasting cap, it may double over the powder core and cause a misfire.

7. Do not twist the safety fuse into the cap and do not use force or violence. If the end of the fuse is flattened or too large, roll it between the thumb and finger.

Cord, Detonating (Primacord). The detonating cord, known commercially as primacord, is a flexible, waterproof fabric tube 0.203 inch in diameter with an explosive core of pentaerythritetetranitrate (PETN). It is used as a detonating agent for high explosives and may be initiated by an electric or nonelectric blasting cap. It may be used to provide a link between the blasting cap and the demolition block when safety fuse is used so that time need not be wasted by burning more fuse than is required. It is also valuable for the firing of a number of shots at some distance apart. PETN has a velocity of detonation of about 19,700 feet per second. It is comparatively insensitive to shock, flame, or friction. It is furnished in 100-foot lengths on wooden spools 7¼ inches long by 3¾ inches in diameter. The cord is greenish-yellow in color, and has a relatively rough, waxy surface.

Obsolete Fuses. There are two fuses formerly used for demolition work which are now obsolete. The first is called instantaneous fuse and consists of a core of loose black powder in a rough braided outer wrapping. Its burning time is 120 feet per second. It was used with miners' safety fuse to increase the length without making an appreciable increase in time. Issue of instantaneous fuse is prohibited, and if any is found it should be reported for destruction.

The second obsolete fuse is called cordeau detonant and consists of a core of TNT in a lead tube about the size of a lead pencil. This fuse has been discontinued for issue and manufacture. It has been replaced by primacord.

Miscellaneous Equipment.

Crimper, cap. The cap crimper resembles a pair of pliers in appearance. It is made of blued steel and is 7 inches long. A hole in

the nose of the crimper is of a diameter that will close the open end of a blasting cap firmly on miners' safety fuse and yet prohibit squeezing the fuse so tightly as to interfere with the burning of the powder train and cause a misfire.

Jackknife. A pocket knife with a sharp blade should be included in demolition equipment for the purpose of slitting safety fuse and cutting twine and tape.

Tape and twine. Tape and twine are included in the equipment for such duties as assembling a number of explosive blocks together to form a charge, securing the blasting cap to the primer block, for wrapping splices and joints of time fuze, for securing a charge to a component and for securing blasting caps to detonating cord.

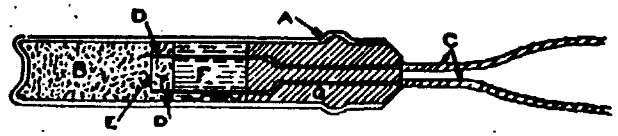
Safety matches. Safety matches of the wooden stick variety are used to ignite miners' safety fuse. Their care should be entrusted to one designated person as no other personnel is permitted to carry matches on explosives operations, and smoking is prohibited. The best method of lighting blasting time fuse with a match is to split the end of the fuse for about 1 inch so that the black powder is exposed, hold the match at right angles to the fuse with the head in the slit and draw the friction surface of the match box across it.

Lighter, fuse. The fuse lighter consists of a thin metal tube containing friction composition, a paper reinforcing tube, and a friction wire attached to a handle. The metal tube has sharp prongs on the inside pointing inward. When the fuse is inserted past these prongs, it will not pull out. Pulling the handle initiates a flame which is transferred to the safety fuse. Fuse lighters are also used in the construction of trap mines.

Preparation of Charges. When a number of demolition blocks are required for the destruction of ammunition components, best results will be obtained by placing the blocks in intimate contact with the item and placing one on top of the other. If three or four blocks are used, two will be placed close together on the wall of the component and the others will be placed on top of those two. If five or six are needed, there will be two layers of two blocks each with the fifth and sixth on top in a third tier. One of the top blocks, with blasting cap and fuse attached, will be inserted into the charge to act as a primer after the other blocks are in place. The blocks may be held in place by tamping moist earth lightly around them or by taping or tying them together and to the component to be destroyed. The fuse should be tied to the primer block about six inches above the blasting cap to prevent it from being pulled out.

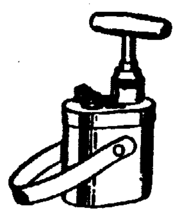
Demolition explosives may be detonated with detonating cord by tying it tightly around the block. Further details on the assembly of charges may be obtained from the Engineer Field Manual, No. 5-25.

AMMUNITION INSPECTION GUIDE

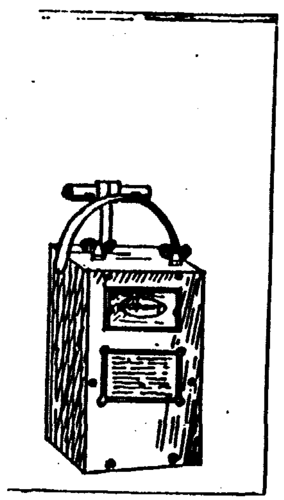


A. COPPER SHELL
B. DETONATING CHARGE
C. INSULATED LEAD WIRES
D. ENDS OF LEAD WIRES PROJECTING INTO CHARGE
E. PLATINUM WIRE BRIDGE
F. PLUG (ASPHALT)
G. FILLING MATERIAL (SULFUR)

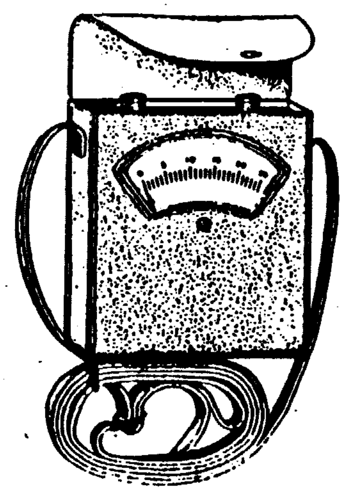
SECTION OF ELECTRIC CAP



10 CAP EXPLODER



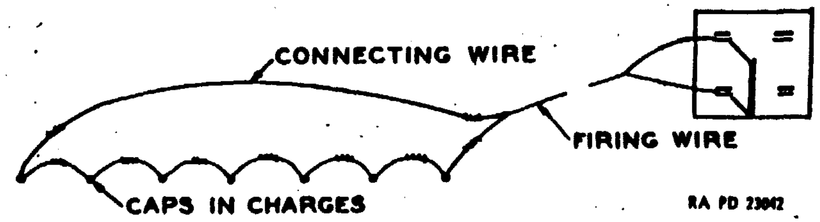
30 CAP EXPLODER



GALVANOMETER

RA PD 23041

Figure 299 — Electric Blasting Equipment



RA PD 23042

Figure 300 — Series Connection

THE ELECTRIC FIRING SYSTEM.

General. An electric firing system consists of a high explosive with an electric blasting cap inserted, a firing wire, and a magneto exploder or blasting machine.

High Explosives. The same explosives for destruction of ammunition are used in the electric system as are used in the nonelectric system.

Cap, blasting, electric. Electric blasting caps for demolition work may be either commercial or special tetryl caps. These caps contain the same explosives as the nonelectric cap and the commercial caps are numbered according to strength in the same way. Special tetryl caps are required positively to detonate TNT.

The explosive charge is contained in the bottom of a copper shell. An asphalt plug is inserted over the explosive and the remainder of the shell is filled with a sulphur filling material. Two 12-foot lead wires are inserted through and kept separated in the filling material and plug which are insulators. These wires extend into the explosive charge and are joined at the ends with a platinum wire or bridge. The lead wires are insulated from the cap outward. If the cap is of the special electric type, the explosive around the platinum wire is a mixture of mercury fulminate and potassium chlorate, and the balance is tetryl. When an electric current is induced through the lead wires, the resistance offered by the platinum bridge produces enough heat to initiate the mixture of mercury fulminate and potassium chlorate.

Safety precautions. The same safety precautions that apply to nonelectric caps also apply to electric caps with the exception of those that deal with the crimping and the holding of the cap in the hand. When using electric caps, the following should be added:

1. Hold the electric cap by the lead wires.

2. Do not pull on the wires of an electric cap.

3. The lead wires should be kept separated during connection to the firing wire to prevent short circuiting.

4. The ends of the lead wires and the ends of the firing wire should be scraped lightly with a knife blade before splicing to insure a good electrical connection.

5. If working on wet ground, the electrical splice between cap lead wires and firing wire should be held in an above ground position by bending the firing wire upward about a foot from the end and securing with mud. This will prevent short circuiting through the ground and consequent misfires.

6. The bared ends of the firing wire should be touched together before being spliced to the cap lead wires to get rid of any static electricity that may have accumulated.

Reel, Firing Wire. The firing wire is issued on a metal reel carrying 500 feet, the total weight of the reel and wire being about 30 pounds. The firing wire is made up of two No. 18 gage (B & S) copper wires, each insulated independently of the other, contained in a rubber cover. The inner end of the firing wire is attached to the reel and is always available for connection to the exploder. The other end is free to be unwound for connection to the charge. If one reel does not provide sufficient distance from the point of explosion for safe cover, two reels may be spliced together by connecting the free end of the wire from one reel to the inner end of the other.

Blasting Machines or Magneto Exploders. The blasting machine is used to generate the current for firing electric blasting caps. It consists essentially of a small portable dynamo or magneto. Blasting machines are issued in two sizes, the 10-cap and the 30-cap exploders.

The 10-cap exploder. This machine will initiate the detonation of 10 electric blasting caps with 12-foot copper wire leads connected in series. It has a possible overload of 100 percent. It is operated by a vigorous twist of the handle; the quicker the twist, the more current is developed. The exploder weighs approximately 5 pounds. If the voltage produced weakens through lack of use, the magneto may be revitalized by connecting the two posts with a short piece of copper wire or other conductor, and twisting the handle in a clockwise direction several times. The handle is easily removable, and for safety should be inserted in the exploder only when ready to fire and should be removed immediately after firing.

The 30-cap exploder. This exploder has a capacity of 30 electric caps with copper wire leads. It weighs about 25 pounds. This machine is operated by a hard downward thrust of the handle to the bottom of its travel.

Safety precautions. The following precautions should be observed in the use and care of the exploder:

1. The exploder should be assigned to the care of one responsible person who should keep it in sight during the whole destruction operation.

2. The firing wires should not be connected to the exploder until all personnel is under cover and the area is seen to be clear.

3. The exploder should not be operated half-heartedly.

4. In case of misfires, the handle of the exploder should be twisted several times to ascertain that enough current is being generated. If the charge still does not detonate, the exploder should be disconnected, revitalized, reconnected and tried again.

Miscellaneous Equipment.

Galvanometer. The galvanometer is an instrument used in demolition work to determine whether a blasting circuit is open or closed; that is, whether the circuit is in proper condition for the blast or, because of defective wiring or other reasons, will fail to transmit the electric current. The instrument is a magnetic device in which an electric current from a small chloride of silver dry cell moves a pointer across a scale. There are two posts conveniently located for connections. When the posts are connected in a closed circuit, the current flows through the galvanometer coil and causes the pointer to be deflected. The amount of deflection depends on the amount of resistance in the closed circuit and on the strength of the chloride of silver dry cell.

The galvanometer should be handled carefully and kept dry. It should be tested before using by placing a short piece of copper wire momentarily across its binding posts. If the needle does not swing freely across the scale, the battery cell is weak and should be replaced. A galvanometer circuit should never be closed over long periods of time because the strength of the chloride of silver dry cell would soon be exhausted.

To test a blasting circuit, touch the two ends of the inner reel firing wire to the two posts of the galvanometer. If the circuit is closed and has a low resistance, the needle will move freely across the scale. If the needle does not move, there is a break in the circuit. If the needle moves only slightly, there is a place of high resistance in the circuit such as a splice or partially broken wire. If the caps are placed in parallel, each cap must be tested individually. Each series in a series parallel circuit must also be tested individually.

Precautions applicable to the use of the galvanometer are as follows:

1. The proper chloride of silver dry cell must always be used, as other cells may have sufficient strength to detonate a cap.

2. All personnel should be under cover when the circuit is tested because it is possible that the caps may be set off by the small amount of galvanometer current.

Preparation of Charges. The only differences between nonelectric and electric charges is the use of an electric cap in the primer block and the electric system for the initiation of the cap. The cap may be secured in the block by looping the cap wires over the block instead of tying with string. A mud pack may serve the same pur-

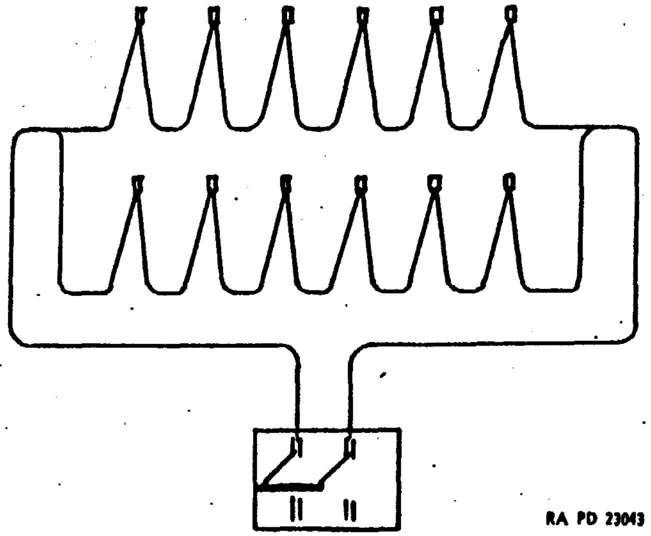


Figure 301 — Two Series Connected in Parallel

pose. A number of charges may be detonated simultaneously by connecting the lead wires of the blasting caps and the firing wire in series. A parallel circuit is rarely used because it necessitates testing each part of the circuit separately. A series parallel circuit is sometimes used, but the parallel connection must be made to the blasting machine since the circuit must be tested from cover. Detailed information of the assembly of charges is given in the Engineer Field Manual No. 5-25.

DESTRUCTION OF ARTILLERY SHELL.

General. The method of destruction of artillery shell varies somewhat with the filler and the construction.

However, the fundamental characteristics of the operation are the same and safety precautions vary only slightly. It should be understood that shell destruction refers only to the projectile. If fixed ammunition is to be destroyed, the cartridge case is removed from the projectile, the propelling charge is burned, the primer is fired and the primer body and cartridge case are salvaged. For better understanding of a destruction operation, it is best to take a specific case and compare other operations to it. The case cited in the following will be the destruction of 155-mm H.E. shell.

Destruction of SHELL, H.E., M107, Unfused, for 155-MM Howitzer M1. In the discussion of a sample destruction, it is best to assume that a number of shell are being destroyed and that, as yet, a site has not been selected for destruction work.

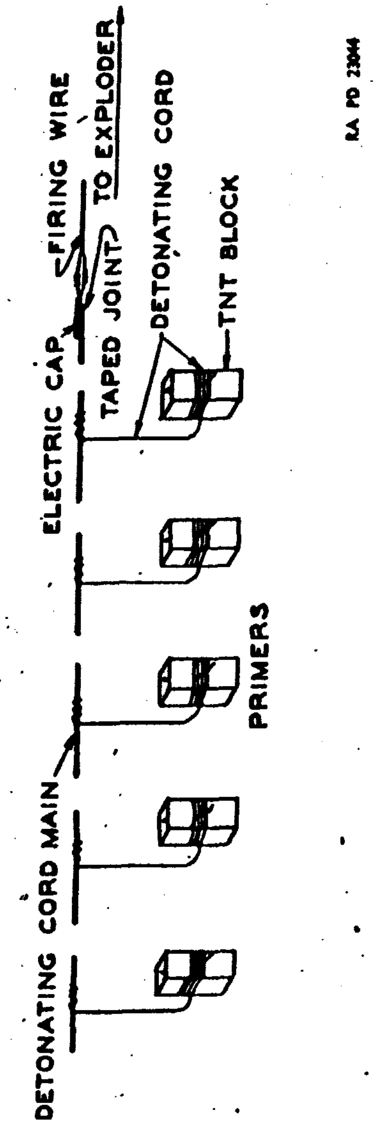


Figure 302 — Use of Detonating Cord

Selection of a demolition ground. The site used for the destruction of ammunition or explosives must be at a minimum distance of 800 yards from inhabited buildings, public railways, public highways, magazines, and operating buildings. (Definitions of these terms may be found in the Ordnance Safety Manual, section V.) Distances from 1½ to 3 miles are desirable. The area around the point of destruction must be cleared of dry grass, leaves, and other inflammable materials for a radius of 200 feet. Shell awaiting destruction will not be piled within 200 feet of the point of destruction and will be protected from grass fires, burning embers, and flying fragments. All dry grass, leaves, and other inflammable materials will be removed within a radius of 50 feet of the piles. Fire-fighting facilities for combatting grass fires should be maintained readily available if practicable.

If an area containing ravines or deep gullies is available, time and labor may be saved. In such case, the charge should be placed in a sharp bend that will block the flying fragments.

Shelter. A bombproof or barricade of sufficient strength to provide protection for personnel from flying fragments or missiles should be erected.

Personnel. The destruction of explosive material requires great care in every detail and should never be attempted by inexperienced or untrained personnel. Trainees must not take part in operations such as preparing charges and caring for blasting caps until they have first observed and been fully instructed on pertinent safety precautions on handling of equipment and explosives. The number of persons engaged in explosive operations should be consistent with the amount of work to be done; under no circumstances will one person be permitted to work alone. In addition to persons required for the work, guards or warning signs will be posted on all roads leading into the danger area to keep unauthorized personnel out during demolition operations.

Every person taking part in the destruction should be instructed as to his specific duties before the operations begin. If untrained personnel are present, pertinent safety precautions should be pointed out.

Transportation. The cargo portion of the truck carrying materials to the demolition grounds for destruction should be lined with boards or canvas. Signs should be displayed on each side and rear with the word "EXPLOSIVES" or a red flag 24 inches square marked with the word "DANGER" in white letters should be displayed. The explosive materials should be covered with a tarpaulin. The driver should be instructed to drive slowly and carefully, especially over rough roads. No more materials should be taken to the demolition grounds than can be destroyed in one day. Upon arriving at the grounds, the motor of the vehicle should be shut off while the explosive materials are being unloaded. The explosives should be covered with a tarpaulin before the motor is started and the truck is driven away.

Preparation of shell for destruction. If the number of shell that may be safely detonated at one time has not been previously determined, it may be found by starting with one shell and building up to a maximum number consistent with safety. This number will vary with conditions at different establishments. The number of shell to be detonated will be carried to the point of destruction and placed in a pit large enough to contain them. They will be piled together in intimate contact in pyramid fashion.

The charge of demolition blocks is placed on one of the top and center shell of the pile and either tied, taped, or packed in place with moist earth. The number of blocks required for the destruction may be found in the following table:

Caliber of Shell	Number of ½-pound TNT Blocks
20-mm, 37-mm, 40-mm	1
75-mm, 76-mm, 3-inch	2
90-mm, 105-mm, 4.5-inch 4.7-inch, 155-mm, 6-inch	3
8-inch, 240-mm	4
10-inch, 12-inch	5
14-inch, 16-inch	6

Never less than the number of blocks shown in the table should be used; it is better to use one more in the case of the larger calibers.

A nonelectric or electric blasting cap is inserted into one of the top blocks in the charge and is secured in place. If TNT blocks are used a special tetryl cap is required; if nitrostarch or dynamite is used, a No. 8 commercial cap or stronger is required. The cap lead wires or miners' safety fuse are laid so that the free ends will not be covered with earth and the shell are covered with three to four feet of dirt. Care should be taken that the earth cover does not include materials that will form dangerous missiles. Personnel should be instructed to pile the earth on the shell carefully so that the blasting cap and explosives will not be jarred. The earth should be piled so that it provides a 3- to 4-foot cover in all directions.

Destruction. If a nonelectric firing system is used, one man is left at the destruction point to light the fuse. The balance of personnel retire to the barricade and one specifically designated person, after making sure that the area is clear, gives the signal for lighting the fuse. The fuse is lighted and the lighter retires to the barricade.

If an electric firing system is used, the lead wires are connected to the firing wire and all personnel retire to the barricade where the other end of the firing wire is located. After the person in charge has made sure that the area is clear and that all personnel are inside of the barricade, the circuit is tested with a galvanometer. If the circuit is closed and has a low resistance, the firing wire is attached to the binding posts of the exploder and the charge is detonated.

The hole resulting from the explosion may be used for the destruction of the next shell, but care should be taken that it has cooled sufficiently. After each detonation, the area should be searched for unexploded materials and if any are found they should be included in the next blast.

Safety Precautions and Use of Equipment. The methods of use and the safety precautions connected with electric and nonelectric firing systems should be applied to any destruction operations in which they are used.

Misfires. If a charge is initiated and does not explode, personnel should remain in shelter at least 30 minutes before investigating the failure. The charge should be uncovered very carefully so as not to disturb the blasting cap and another block should be primed with a new cap. This new primer is then exploded as before. Slight movement of the blasting cap that failed to function may result in an explosion. Heating caused by the electric current or flame from the fuse increases the sensitivity of the initiating explosive.

Shell Loaded With Explosive D. Shell loaded with explosive D must be destroyed one at a time. The filler is so insensitive that it will not detonate sympathetically. For the same reason, more demolition blocks are needed than for the destruction of shell loaded with TNT or amatol.

Shell Fitted With Adapter Boosters. Shell fitted with adapter boosters can be detonated without the use of demolition blocks by placing a special tetryl cap in the fuze cavity and sealing the opening with mud.

Chemical Shell. Shell with chemical fillers may be detonated as outlined in the destruction of 155-mm H.E. shell. The following precautions are added:

1. As chemical shell contain a comparatively small amount of exstroyed, water should be poured on the ammunition until no smoke should be double the number specified for high-explosive shell of equal caliber.

2. The chemical shell to be destroyed, excepting those filled with phosphorus, should be destroyed a single shell at a time, in a pit at least 6 feet deep. Phosphorus shell should be destroyed on top of the ground so that when the shell is split open, air will be available.

3. The point at which H shell are to be exploded should be chosen so that personnel can be excluded for a period of approximately 48 hours from the area 1 mile down wind from where the shell is to be

exploded. Also, personnel must be prevented from passing within a distance of 150 yards from the point of destruction for a period of about 2 weeks. When the charge has been set, the 6-foot pit is backfilled and the charge is exploded. The hole made by the blast should be filled with a mixture of dry bleach powder and earth. Place a permanent sign on the fill prohibiting digging. When shell containing persistent gases other than mustard are to be destroyed, specific instruction should be requested from the office of the Chief of Ordnance.

4. If leaking ammunition loaded with phosphorus is to be destroyed, water should be poured on the ammunition until no smoke is visible before the demolition blocks are placed for detonation.

5. Personnel engaged in the destruction of chemical ammunition will wear adequate protective equipment and clothing and will have necessary first aid supplies on hand.

Shrapnel.

Conventional method. The destruction of shrapnel cannot be accomplished by mass detonation as in the case of H.E. loaded shell. A shrapnel projectile with the time fuze removed may be destroyed by placing a blasting cap in the flash tube. The cap should be pushed down the tube carefully until it touches the bottom. The nose should be closed around the safety fuse or cap lead wires, as the case may be, with damp earth. If an electric system is used, the cap may be further secured by folding the lead wires back and taping them to the nose of the shell. When shrapnel is exploded in this manner, the projectile case recoils with a tremendous velocity and will escape from the pit unless backed up by a strong perpendicular surface.

Alternative method. The shrapnel is buried, base first, into the side of a 6-foot pit (large enough for operations described) for about three-quarters of its length and with the nose pointing slightly downward toward the bottom. A blasting cap is inserted into the flash channel as described in the conventional method. When the cap is initiated, the shrapnel case will be driven farther into the earth and the balls will be propelled into the bottom and opposite side of the pit. Several shrapnel may be detonated simultaneously by burying them in the sides of the pit and detonating them with electric blasting caps connected in series. Special tetryl caps are not required for detonating shrapnel because their only purpose is to initiate the black powder base charge.

DESTRUCTION OF AIRCRAFT BOMBS.

Compared With Destruction of Articllery Shell. Bombs may be destroyed in accordance with the instructions for the detonation of artillery shell. However, the following should be noted:

1. Bombs contain much larger quantities of explosives by percent of total weight than artillery shell. The number detonated at one time must be reduced accordingly.

2. Bombs have thin walls and detonate so readily that fewer demolition blocks are required for their destruction.

3. Since bombs filled with high explosive are subject to mass detonation, they should be segregated into small piles at least 100 feet apart and at least 300 feet from the point of destruction. Protection must be provided that will shield the piles against fragments or missiles.

4. The destruction of bombs larger than 100 pounds will not be undertaken without specific instructions from the Office, Chief of Ordnance.

DESTRUCTION OF TRENCH MORTAR SHELL, ANTITANK MINES, AND ROCKETS.

These components have greater amounts of filler as compared to total weights than artillery shell so that fewer components should be destroyed at one time. Otherwise the destruction procedures are the same as for artillery shell. The part containing the propelling charge is removed from the rocket before it is detonated. Since these components have thinner walls than artillery shell, fewer demolition blocks are required for their destruction.

DESTRUCTION OF OFFENSIVE HAND GRENADES AND RIFLE GRENADES.

Grenades, up to a total of 40, should be packed in a box in intimate contact with each other and placed in a pit. Approximately 1 block for each 6 grenades is placed on top of the grenades. One of the top blocks in the pile should be fitted with a blasting cap. A lid should be placed over the box and the box should be covered with 3 or 4 feet of earth. Care should be taken not to pinch the safety fuse under the lid if safety fuze is used. All applicable safety precautions set forth in the discussions of the detonation of artillery shell and the nonelectric and electric firing systems will be observed.

DESTRUCTION OF FUZES, PRIMERS, DETONATORS, BOOSTERS, AND BURSTERS.

A small quantity of these components should be placed in a box of appropriate size in intimate contact. The box should be placed in a pit large enough to contain the box. One demolition block is fitted with a blasting cap and placed on top of the components. A lid should be placed on the box, and 3 or 4 feet of earth should be

provided as a cover. The charge should then be exploded in accordance with all applicable safety precautions set forth for destruction of artillery shell and use of electric and nonelectric equipment. It should be particularly noted that the quantity of explosive in these components, especially in the case of primers, is so large in proportion to the total weight of the unit that small quantities only should be exploded and then only with extreme caution.

DESTRUCTION OF PHOTOFLASH BOMBS.

Photoflash bombs may be treated as thin-walled artillery shell for destruction. Personnel should be instructed not to look in their direction when they are detonated as the flash is blinding.

DESTRUCTION OF DUDS.

General. Ammunition inspectors may sometimes be called on to destroy duds. Duds are marked where found with a red flag and then are reported. Amateurs should leave duds strictly alone because components that have been initiated and have failed to function are extremely dangerous to handle. They should not be moved but should be destroyed wherever found, if practicable. Should it be necessary to move a dud, great care should be taken not to cause movement of the internal parts. Such action may result in immediate explosion.

Detonation. The detonation of duds is carried out in the same manner as described for whichever type of component it happens to be. Added caution must be exercised in not jarring the dud in any way. If the dud is on a target range where shelter is not available, it is usually detonated, using a nonelectric firing system. A length of safety fuse that will give personnel time to get a safe distance away will be used. If the explosive content is large and facilities are available, a conveyance may be used to carry personnel to a safe distance.

DESTRUCTION OF OTHER COMPONENTS.

Components of the same nature of those discussed in this chapter but not included must not be destroyed without specific instruction from the Office, Chief of Ordnance. When exceptionally large quantities are to be destroyed, specific instructions will be requested from the Office, Chief of Ordnance.

FURTHER REFERENCES: A complete list of references with regard to disposal of unusable ammunition will be found at the end of this section.

Chapter 3
Destruction by Burning

GENERAL.

Types of Explosives and Ammunition Destroyed by Burning. The types of explosives and ammunition destroyed by burning are as follows:
Black powder
Smokeless powder
High explosives (TNT, tetryl, explosive D)
Pyrotechnics
Small-arms ammunition
Primers, fuzes, detonators, and boosters
Fragmentation grenades
Chemical ammunition filled with H

Selection and Preparation of Grounds. In choosing a burning ground, bad lands with gullies, etc., should be utilized. The burning ground should not be closer than ¼ mile to the nearest inhabited building, public railway, public highway, magazine, or operating building. (Definitions of these terms may be found in section V of the Ordnance Safety Manual.) Greater distances are desirable. All dry grass, leaves, or other inflammable materials must be cleared from around the point of destruction for a radius of 200 feet. Material awaiting destruction must be 200 feet from the point of destruction and the area around this material should be cleared of dry grass, leaves, and other inflammable materials for a radius of 50 feet.

Transportation. The cargo portion of the truck must be lined with boards or canvas and the material being transported must be covered with a tarpaulin. Signs on each side and rear with the word "EXPLOSIVES," or a red flag 24 inches square marked with the word "DANGER" in white letters must be displayed. The driver should be instructed to drive carefully, especially over rough roads. While the material is being unloaded at the burning grounds, the motor of the vehicle must be stopped. The explosive material must be covered with a tarpaulin while the motor is started and the truck drives away. No more than 1 day's supply will be taken to the burning ground.

Personnel. The destruction should be accomplished by trained personnel under the direction of a competent supervisor. Trainees will be fully instructed and will observe operations before taking part. Unauthorized personnel will not be permitted in the area while burning of explosives or chemicals is being accomplished. There should never be more than the required number of persons on the job, and never will there be less than two.

General Safety Regulations. The general safety regulations applicable to destruction by burning are as follows:

1. Facilities for fighting grass fires will be maintained readily available. When exceptionally large quantities of explosives are being burned, the fire department should be notified.

2. Unless otherwise specified, material to be burned will always be removed from containers as attempts to burn certain explosives under even slight confinement may result in detonation.

3. In repeated burning operations, care will be taken to guard against material being ignited from burning residue or heat retained in the ground. It is wise to select a new spot for each burning and not to reuse ground until 24 hours have elapsed.

4. Matches will be of the wooden stick safety variety and will be carried by one designated person only. Smoking will be strictly prohibited during burning operations.

5. When explosives in a train, pit, or trench are being ignited with inflammable material, all personnel except the person doing the lighting should retire to a safe distance. After lighting the material the lighter must also take cover.

6. If practicable, the ground at the point of destruction should be wet down with water at the close of each day's operation.

DESTRUCTION OF BLACK POWDER.

Containers. Black powder containers will be opened with tools of wood or nonsparking metals. The contents of only one container will be destroyed at a time. The emptied container will be thoroughly rinsed with water since serious explosions have occurred with supposedly empty black powder cans. The safest method of destroying black powder is to dump it into a stream or body of water since water dissolves the nitrates and renders the powder ineffective. If no suitable stream is available, it may be burned.

Burning. The powder must be removed from the container and spread out in a trail about 2 inches wide, care being taken that no part of the trail parallels another part within a distance of 10 feet. The ground over which the trail is laid must be free from cracks or other depressions in which the powder might be confined. A train of inflammable material, such as excelsior, at least 10 feet long and laid so that when it is ignited it will burn with the wind is used to ignite black powder. The ignition of black powder results in a flare or explosion so quickly that there is no chance to withdraw after the powder ignites.

There is some controversy over the position of the igniting train. Some persons believe that the powder should be ignited against the wind so that the train will burn more slowly and allow the person igniting it more time to get safely away. Others believe that if an igniting train 10 feet long is used and the powder train is properly laid upward, the igniter will have plenty of time to get away and in case of accidental ignition of the powder the wind will carry the sudden intense heat away from the trapped person. The latter, while recent, is very good reasoning.

BURNING OF SMOKELESS POWDER.

Bulk Smokeless Powder, Up To 500 Pounds. Quantities of less than 500 pounds of bulk smokeless powder may be burned safely if the powder is removed from the container and spread on the ground in a thin layer or train not over 3 or 4 inches thick. If the powder is transferred to a small-arms box, it will facilitate the spreading of the train. A train of inflammable material, or a very thin train of the powder itself, about 10 feet long and laid so that the lighter has the wind blowing toward him should be used to ignite the powder.

Bulk Smokeless Powder, Up To 5,000 Pounds. Quantities up to 5,000 pounds may be burned in a pit or trench if a train of inflammable material, at least 25 feet long and on the down-wind side, is used to ignite the powder. When such large quantities are burned, a shield, at least 200 feet away from the point of destruction, should be erected to protect personnel from the intense heat.

Propelling Charges. When separate loading propelling charges are to be destroyed, the smokeless powder will be removed from the bag at the burning ground by slitting the end opposite the igniter pad with a safety knife. The slit is enlarged by tearing and the smokeless powder is poured into a container which should be open only while receiving powder. This powder will be burned in accordance with the procedures for burning bulk smokeless powder.

The igniters and bags upon being emptied will be submerged immediately into a container of water. The igniter pad will be slit with a safety knife while being held under water and the black powder emptied. The igniter pads and cartridge bags will remain under water for a period of about 3 days, after which, they should be spread out into the open until thoroughly dry. When the igniters and bags are dry, they may be burned in a pit or trench taking care to limit the amount destroyed at one time to a safe number and to ignite them with an inflammable train. Bags and igniters awaiting destruction must be protected against accidental ignition.

BURNING OF HIGH EXPLOSIVES (TNT, TETRYL AND EXPLOSIVE "D").

High explosives such as TNT, tetryl, and explosive "D" will be destroyed by burning. A bed of excelsior should be prepared and the explosive should be spread on top of it in a thin layer, not over 3 or 4 inches thick. TNT box tops and wrapping paper may be substituted for excelsior as a bed. If the boxes are to be destroyed, they may be

placed along the sides of the bed. A train of inflammable material at least 10 feet long should be used to ignite the explosive from the down wind side. Personnel will retire to a safe distance so that the wind will blow the smoke and fumes away from them. The gases formed in the burning are poisonous.

If it becomes necessary to burn other high explosives such as fulminate of mercury, dynamite, picric acid, etc., special instructions will be requested from the office of the Chief of Ordnance.

BURNING OF PYROTECHNICS.

Pyrotechnics, Except Parachute Flares. Pyrotechnics, except parachute flares, will be destroyed in quantities consistent with safety in a trench about 4 feet deep. A quantity of excelsior, wood, or similar inflammable material sufficient to produce a good hot fire will be placed in the bottom of the trench. The pyrotechnics to be burned will be removed from their containers and placed on top of the inflammable material. A cover of heavy iron grating or wire mesh should be placed over the pit and staked down. The fire is lighted from the down-wind side with a train of inflammable material.

Parachute Flares. Parachute flares will be destroyed in the same manner as other pyrotechnics except that they will be placed on their ends atop the inflammable material with each flare separated by a distance of at least 4 feet. No cover is placed over the pit. It is imperative that personnel have good protective cover or withdraw to a safe distance since the flares are subject to detonation.

BURNING OF SMALL ARMS, PRIMERS, FUZES, DETONATORS, AND BOOSTERS.

The Pit and Chute Method. A pit which is approximately 6 feet square and 4 feet deep is dug. An inclined chute, such as a piece of 4-inch pipe, should be provided and should be placed so that one end is over the center of the pit and the other is behind a barricade. The end of the chute behind the barricade should be baffled and should be higher than a man's head. The chute may act as a rifle barrel for fragments flying from the pit. The pipe must be securely braced. A hot fire should be built in the pit and covered with sheet iron or other material suitable to confine flying fragments. Openings must be left for draft.

Components containing small amount of explosives such as small arms and 21-grain percussion primers may be fed through the pipe into the fire several at a time. This quantity may be properly limited by using a dipper. Fuzes, detonators, boosters, and large primers must be dropped into the pit one at a time and the explosion heard before another is dropped. If the small-arms ammunition does not sound like double machine guns when dropped into the pit, the operation should be discontinued. After 30 minutes, more fuel should be put on the fire and the operation continued.

Other containers may be substituted for the pit if they are strong enough to withstand the pressure of the explosions. An example is a square container of approximately ½-inch armor plate which is welded together. The container is set up on hollow cement building blocks and a good hot fire built under and around it. A heavy lid is put over the top and has small holes drilled in it to prevent its being blown off. The pipe runs through this lid. Holes may also be drilled around the top of the container to reduce pressures. Small holes about 2 inches apart may be drilled in the bottom. The container must be given ample time to become heated before any components are dropped in.

Burning in a Trench. *Primers smaller than 100 grain may be* burned in a trench approximately 2 feet deep, 1 foot wide, and of sufficient length to accommodate the number of primers to be burned at one time. A quantity of excelsior or similar combustible material sufficient to insure a good hot fire throughout its length should be placed in the bottom of the trench. The primers must be removed completely from their containers and placed on the combustible material before the fire is lighted. A piece of sheet metal should be placed over the trench to confine fragments. Sufficient space should remain uncovered at the ends to allow a draft through the trench. The combustible material is lighted with an inflammable train.

DESTRUCTION OF FRAGMENTATION GRENADES.

Grenades are destroyed by unscrewing the fuze from the body, emptying the EC blank powder into a barrel of water, and destroying the fuzes by the pit and chute method. The EC blank powder may be later spread out on the ground, allowed to dry, and burned in accordance with the procedures outlined for black powder. If the fuzes do not disassemble easily, the grenades should be destroyed with demolition blocks like offensive and rifle grenades.

DESTRUCTION OF CHEMICAL COMPONENTS FILLED WITH H.

General. When chemical ammunition containing mustard cannot be dumped at sea and a sufficiently isolated area is not available for static firing, it must be destroyed by one of the following methods. The precautions discussed in the chapter on storage of chemical ammunition will apply to the transporting and handling of the ammunition. Personnel will wear complete protective clothing and equipment. The appropriate first aid supplies must be on hand.

Burying. A small hole (about ¼ in.) is drilled into the void space of the component. A handful of waste or cloth wadding saturated with 5 percent bleaching powder solution should be held around the

point where the hole is being drilled to absorb any H vapor emitted when the drill pierces the component. The hole is then reamed or drilled to a diameter large enough to allow the mustard to be poured out. The H is then poured over a pile of loose earth and bleaching powder mixture in the bottom of a hole about 5 feet deep, dug at least 200 yards from well sites, streams, or bodies of water. Personnel must have the wind blowing away from them during this operation. The pile of loose earth and bleaching powder mixture in the bottom of the hole should consist of an intimate mixture of about 1 bushel of earth and 1 bushel of ordinary bleaching powder (35 percent chlorine). The emptied shell should be placed on top of the bleaching powder and the hole back filled to within a foot or so of the top. Then, approximately a barrel of water should be poured into the hole and the back filling completed. If HTH (bleaching powder containing 65 percent of available chlorine) is used instead of ordinary bleaching powder, only about one half as much is needed. A permanent sign should be placed on the fill prohibiting digging in the vicinity. The quantities given in this discussion are based on 155-mm shell which contain approximately 11 pounds of mustard. In cases where contents are greater or smaller, the amount of bleaching powder and earth must be changed accordingly.

Burning. A mustard component opened by drilling may also be destroyed by pouring the contents uniformly over a closely packed pile of wood containing about ¼ cord and laying the component on the top. The wood is then set on fire and personnel excluded from the down-wind area to a distance of 200 yards while the wood is burning. If the shell is heated to a red heat in this method of disposal, mustard adhering to the shell walls will be destroyed. If the shell contains a burster charge, the charge should be removed before the shell is placed on the wood. In emptying the shell, personnel should be placed so that the wind will blow the gas away from them. Drilling tools contaminated with mustard should be cleaned thoroughly by immersing in a 5 percent solution of bleaching powder for 10 or 15 minutes and then washing with water.

FURTHER REFERENCES: References will be found at the end of the last chapter in this section.

Chapter 4

Dumping at Sea

GENERAL.

The safest and easiest way to destroy unusable ammunition is to dump it at sea. The items disposed of in this manner must be of sufficient weight to sink to the ocean floor. Only at establishments located near a deep sea waterway is this method practicable. Port authorities must be consulted prior to taking explosive materials out to sea.

TRANSPORTATION.

Personnel supervising the loading of boats and barges should be familiar with Army Regulation No. 55-470. Unless a definite location for dumping is designated by the local port authorities, no explosive material should be thrown overboard within a distance of 10 miles from shore. An effort should be made to locate a deep place or a ledge sloping seaward. Instances are on record of heavy items of ammunition being washed ashore from almost incredible distances. During daytime transit, the boat or barge will display a red flag 4 feet square at least 10 feet above the top deck. At night, a red lantern is substituted for the flag. A competent man on board must be on the alert to signal approaching vessels of the cargo.

DUMPING.

All precautions relative to the safe handling of the various types of ammunition being destroyed will be carefully obeyed. All materials must be carefully removed from their packing before being dumped overboard. Great caution must be exercised to see that none of the items strike together or strike any part of the boat or barge.

FURTHER REFERENCES: *The following references apply to all methods of destruction of unusable ammunition and explosives:* FM 5-25, Engineer Field Manual; TM 9-1900, Ammunition General; O.O. 7224, Ordnance Safety Manual; SNL R-7; Training films; 5-270, Explosives and Demolition, TNT; 5-271, Explosives and Demolition, Nonelectric blasting equipment; 5-272, Explosives and Demolition, Electric blasting equipment, 9-2007, Destruction of Unusable Ammunition, Burning; 9-2008, Destruction of Unusable Ammunition, Detonation; 9-2009, Destruction of Unusable Ammunition, Dumping at sea; AR 55-470.

SECTION X.

MAGAZINE AREA

Chapter 1

Magazine Construction and Inspection

GENERAL. *The end of World War I found this country with tremendous stocks of ammunition, powder, and bulk explosives. Proper storage facilities were not available for this quantity of material, and makeshift arrangements were found necessary. Among the early types of storage, wooden buildings, open sheds, and even outdoor storage with tarpaulin protection were resorted to. As might be expected, this type of storage proved unsatisfactory in many ways.*

Exposure to excessive heat and moisture accelerated deterioration.

Nonfireproof construction permitted an exterior fire to destroy and explode the ammunition and explosives.

Lack of lightning protection caused a considerable hazard during thunderstorms.

Nonbulletproof construction permitted accidental shooting into magazine to set off some types of material so stored.

It is the purpose of this discussion to indicate the improvements made as evidenced by modern construction of magazines.

There are at present two distinct types of magazines: the above ground, and the underground or igloo. The tendency at new depots under construction is to make all magazines of the standard underground type.

ABOVE GROUND MAGAZINES.

Description. A typical modern above ground magazine has concrete foundation walls and piers. The walls are of hollow tile with or without a sand filler. The sand filler is for the purpose of preventing missiles from penetrating the hollow walls. The framework is of steel, and the floor is of concrete which may be covered with a sparkproof covering. A double pitched roof supported on steel trusses is used over a ceiling of corrugated asbestos with fireproof rock-wool insulation. The ceiling is attached to bottom chords of roof trusses.

It will be noted that the construction is fireproof. In addition, where the type of storage warrants it, the hollow tile walls are filled with sand to stop rifle bullets. This is especially important in storage of items such as black powder.

The use of hollow tile walls comes as the result of observations made at the scene of explosions in magazines. Often the radius and extent of the damage was spread by missiles formed from the bricks of which the magazines were constructed. The hollow tile construction is expected to pulverize under the force of an explosion, thus preventing large missiles from being formed.

SECTION XIII.

SURVEILLANCE — GENERAL

Chapter 1

Introduction

PURPOSE

The purpose of this bulletin is to provide a ready reference and standard for the use of ordnance technical personnel, covering all phases of surveillance activities in connection with ammunition, ammunition components, and explosives procured, stored, and issued by the Ordnance Department.

SCOPE.

This bulletin gives general and specific information and instructions regarding surveillance problems connected with the normally expected rate of deterioration; approved methods of control; methods of securing and verifying information as to the immediate condition; inspection of facilities used in connection with activities involving destruction of unserviceable units; and maintenance of ammunition, ammunition components, and explosives at establishments under the control of the Chief of Ordnance and in the hands of troops, but under the general supervision of the Ordnance Department.

This bulletin also covers duties of ammunition inspectors when assigned to establishments under the control of the Chief of Ordnance, service commands, ports of embarkation, the Army Air Forces, and the overseas departments

All mandatory requirements of this bulletin, in which the terms "will" or "must" are used, will be complied with unless specific authority to the contrary is granted by the Chief of Ordnance. The advisory provisions, in which the terms "may" or "should" are used, will be complied with wherever practicable, or unless modified by authorization of the commanding officer.

GENERAL DEFINITIONS.

Surveillance. The observation, inspection, investigation, test, study, and classification of ammunition, ammunition components, and explosives, with respect to their serviceability, hazard, and rate of deterioration.

Safety. The planning, methods, activities, and resultant conditions, having to do with the receipt, inspection, handling, movement, storage, surveillance, shipment, assembling, loading, renovation, maintenance, and destruction of ammunition, ammunition components, and

explosives, in such a manner as to create the minimum practicable hazard to life and property.

Ordnance Establishment. An establishment under the direct control of the Chief of Ordnance.

Munitions. A general term for all necessary war materiel, including ammunition, ammunition components, and explosives.

Ammunition. Denotes all types of munitions, and components thereof, used by troops in warfare, or training therefor, which are designed to cause destruction of life and property, or produce signals incident thereto. Ammunition may be placed, thrown, discharged from weapons, or dropped, to reach desired point of functioning.

Chemical Ammunition. Munitions, or components, in which the filler, by means of chemical action on functioning, produces a toxic or irritant effect on the body, a screening smoke, or an incendiary action.

Ammunition Component. Any part of a complete round of ammunition; it is usually loaded (commonly called "live"), or it may be inert (inactive).

Explosive. A chemical compound or mechanical mixture commonly used or intended for producing an explosive effect.

Hazardous Materials. Ammunition, loaded ammunition components, explosives, inflammables, and toxic substances.

Inflammable Substances. Highly inflammable liquids are those which give off inflammable vapors at or below 80 F with a flash point below 80 F; inflammable liquids are those which give off inflammable vapors above 80 F with a flash point higher than 80 F. Inflammable solids are those (other than explosives) which, under conditions incident to handling, storage, or transportation, are liable to cause fires.

Toxic Substances. Any liquid, solid, or gas which may, by contact, produce a toxic or irritant effect on the body.

Class. A grouping of ammunition, ammunition components, or explosives having like or similar storage hazards.

Lot. A quantity of one item of ammunition, ammunition components, or explosives, manufactured or assembled in one plant from raw materials or components of the same physical characteristics, under uniform conditions, and meeting definite physical and chemical requirements of War Department specifications and drawings.

Grand Lot. A group of lots of the same type of ammunition, ammunition components, or explosives, having the same technical history: i.e., lots of the same manufacturer, manufactured at about the same time and under like conditions and specifications, handled and stored under like conditions, and giving approximately the same range of results in test and use.

Magazine. Any structure used for the storage of ammunition, loaded ammunition components, or explosives.

Magazine Area. An area specifically designated and set aside for the storage of ammunition, loaded ammunition components, or explosives.

Explosives Area. An area specifically designated and set aside for the manufacture, loading, maintenance, renovation, salvaging, or for otherwise handling ammunition, ammunition components, or explosives. NOTE: Small stocks of completed items, components, or raw materials may be stored in, or shipped from an explosives area.

Operating Building. Any structure, except a magazine, in which operations pertaining to manufacturing, processing, packing or shipping of ammunition, ammunition components, or explosives are performed.

Auxiliary Building. Any nonoperating building (including service magazines) serving operating buildings, lines, or plants.

Service Magazine. Any magazine used for the storage of a limited supply of ammunition, ammunition components, or explosives to service an operating building, line, or plant.

Line. A succession of operating and auxiliary buildings along which munitions move in process of manufacture and for assembly.

Plant. One or more lines, together with the necessary utilities and buildings for shops, storage, administration, and other activities.

Ammunition Inspectors Workshop. A special building at an ordnance depot equipped and located to permit all normal surveillance inspections to be made therein. The ammunition workshop at the newer depots is constructed in accordance with approved ordnance drawing 19-3-559.

Popping. A term applied to the treating of empty or fired cartridge cases for small-arms ammunition by exposure to heat, to insure functioning of all contained primers prior to shipping as scrap.

Maintenance. The maintaining of stocks of ammunition, ammunition components, and explosives in serviceable condition for immediate use.

Reconditioning. Recurrent maintenance operations required from time to time for the protection of the exterior surfaces of individual units and/or packages of ammunition, ammunition components, and explosives.

Renovation. Special maintenance operations required to renew serviceability, and involving replacement of a component or group of components in ammunition and, in some cases, ammunition components.

Salvage. Operations involving the disassembly and/or unloading of ammunition or ammunition components for the purpose of recovering from them all materials or components which are or may be made serviceable, or which may have a value as scrap.

The foregoing definitions will be amplified and specific definitions offered in pertinent sections of this bulletin, as required.

DATA USED.

The information contained herein is largely a compilation of routine and technical data based on many years of experience by field and technical personnel of the Ordnance Department. Due to the very nature of the subject, it is not possible to lay down hard and fast rules for universal application, especially since climatic and storage conditions play such a large part in the expected service life, and normally expected rate of deterioration, of ammunition, ammunition components, and explosives. It is, however, contemplated that this bulletin will cover the general phases of surveillance problems and control, although ordnance officers and technical personnel of ordnance establishments will, of necessity, be required to consider local conditions of climate and storage in the application of this information to surveillance activities.

Among the data, references, and sources of information considered in the preparation of this bulletin are the following:

1. Reports and records covering the surveillance of ammunition, ammunition components, and explosives on file in the Office of the Chief of Ordnance.

2. The Ordnance Safety Manual, O.O. Form No. 7224.

3. Ordnance Department Orders and Ordnance Department Safety Bulletins pertinent to the subject.

4. Pertinent Army Regulations, Technical Manuals, Field Manuals, War Department specifications and drawings, Ordnance Shipment and Storage Charts, Standard Nomenclature Lists, Ordnance Field Service Bulletins, and other instructions issued by the Chief of Ordnance.

Chapter 2
Surveillance

GENERAL.

The term "surveillance" as used herein includes the observation, inspection, investigation, test, study, and classification of ammunition, ammunition components, and explosives in movement, storage, and use, with respect to degree of serviceability and rate of deterioration;

the inspection of the containers and buildings in which they are stored; the inspection of facilities and methods used in handling, storing, shipping, manufacturing, maintaining, reconditioning, renovating, salvaging, and destroying ammunition, to insure compliance with the provisions of the Ordnance Safety Manual, O.O. Form No. 7224; and the preparation and maintenance of all technical data, reports, and records, required by the above-listed activities.

The objective of surveillance is to detect any increase in the expected normal rate of deterioration in ammunition, ammunition components, and explosives; to determine the state and nature of deterioration and the degree of serviceability; to correct or control storage conditions and handling methods affecting same; to detect dangerous conditions affecting the serviceability and increasing the hazards of storage and use; and to segregate or destroy seriously unstable units, as required.

RESPONSIBILITY FOR SURVEILLANCE.

The Chief of Ordnance exercises general supervision over the surveillance of all ammunition, ammunition components, and explosives in storage and service; prescribes the technical methods of inspections, investigations, and tests; and maintains records of the condition and serviceability of all lots in storage and service.

The commanding officer of an ordnance establishment is responsible to the Chief of Ordnance for insuring that all ammunition, ammunition components, and explosives at his establishment are subjected to proper surveillance; that the results of surveillance observations, inspections, investigations, and tests are promptly reported; and that the Chief of Ordnance is furnished a record by lot number of the condition of all ammunition, ammunition components, and explosives on hand. He is also responsible for seeing that the requirements of the Ordnance Safety Manual are complied with, and that all instructions and recommendations from the Chief of Ordnance are promptly acted upon.

AMMUNITION INSPECTORS.

Ammunition inspectors are employees of the Ordnance Department at large, who by virtue of their training and experience are qualified to conduct observations, inspections, tests, and investigations to determine the current degree of serviceability as affected by the various conditions of storage, handling, manufacture, maintenance, and renovation of ammunition, ammunition components, and explosives; to determine the degree of deterioration and hazards induced thereby; to recommend to the commanding officer such methods of control as may be required for the maintenance of approved standards; and to keep the commanding officer advised as to the application of same.

The Chief of Ordnance appoints, prescribes training for, and assigns ammunition inspectors to ordnance establishments and activities

as required; when so assigned the ammunition inspectors are under the administrative control and supervision of the commanding officer, but remain under the technical supervision of the Chief of Ordnance.

The ammunition inspector at an ordnance establishment or activity where operations or conditions are of such magnitude as to necessitate additional trained or technical personnel, will be supplied with a sufficient number of ammunition inspectors, junior in grade, to perform properly the duties assigned to his office and to receive additional instruction and training in surveillance.

DUTIES OF AMMUNITION INSPECTORS.

Duties normally performed by ammunition inspectors assigned to ordnance establishments and activities are outlined herewith:

At an Ordnance Depot.

1. Acts as a technical adviser to the commanding officer on all matters pertaining to surveillance and safety in connection with ammunition, ammunition components, and explosives.

2. Conducts annual and routine observations, inspections, and tests on all types of ammunition, ammunition components, and explosives.

3. Maintains and operates a surveillance laboratory, workshop, and equipment, as required.

4. Conducts all special inspections, tests, or investigations in connection with determination of quality, safety, or deterioration of ammunition, ammunition components, and explosives in accordance with instructions from the Chief of Ordnance.

5. Prepares and maintains accurate records of all observations, inspections, investigations, and tests on depot surveillance record cards (O.O. Form No. 5999), and such other records as may be required.

6. Maintains file and index for all drawings and specifications covering ammunition, ammunition components, explosives, and methods of packing and storing.

7. Inspects the vehicles carrying all incoming and outgoing shipments of ammunition, ammunition components, and explosives for presence of sabotage devices; property of closure, staying, and loading methods; condition and serviceability of contents; and compliance with existing instructions and regulations governing same.

8. Inspects dunnage used, and methods of storage of ammunition, ammunition components, and explosives for compliance with specifications, drawings, and safety regulations.

9. Inspects all facilities and methods used in connection with storage, handling, shipping (in accordance with paragraph 57 of the Ordnance Safety Manual), assembling, loading, maintaining, reconditioning, renovating, salvaging, and destroying ammunition, ammunition components, and explosives for compliance with existing safety regulations; corrects same, and reports necessity for action taken where violations are found.

10. Makes formal monthly inspection of all magazines and buildings storing ammunition, ammunition components, and explosives (including smokeless powder), to assure compliance with all standards of storage, including inspection of surrounding areas for freedom from fire hazards and other nonstandard conditions, and the taking and recording of maximum and minimum temperature readings; and guards against the presence of nonstandard conditions conducive to accelerating the normally expected rate of deterioration or creating a hazard to the items in storage. The results of this inspection should be made a matter of record, and the pertinent portions of the data should be considered as pertaining to the technical history of the items in storage.

11. Inspects and tests the lightning protection system in the magazine and/or explosives areas, as prescribed in paragraph 30 *d* of the Ordnance Safety Manual, and recommends repairs or improvements to the system where necessary.

12. Conducts such acceptance and production tests as are required to be performed at the depot in connection with assembling, loading, or renovation operations; prepares such records and reports as may be necessary.

13. Supervises selection of samples for shipment to proving grounds or laboratories, for ballistic and surveillance tests or investigations, in accordance with specifications and special instructions issued by the Chief of Ordnance.

14. Supervises, guides, and trains junior ammunition inspectors, maintains a general record of their progress and ability, and submits semi-annual reports as to their progress and development in accordance with current instructions issued by the Office of the Chief of Ordnance.

15. Acts as an instructor in surveillance and safety to officers, trainees, and depot personnel.

16. Acts as technical consultant in determining suitability and serviceability of issues.

17. Maintains a data card file of all lots of ammunition, ammunition components, and explosives in storage.

18. Initiates and maintains proper correspondence, records, and reports to cover all activities engaged in.

19. Acts as ordnance representative aboard Army transports during loading and unloading of ammunition, ammunition components, and explosives when performed through depot or local port facilities.

20. Performs such additional related duties as may be assigned by the commanding officer; for example, he may be made responsible for

properly equipping the depot to handle chemical ammunition and for the inspection and maintenance of that equipment, which includes items of protective clothing.

At a Service Command. The following duties are suggested as being within the capabilities and qualifications of the ammunition inspectors assigned to duty at a service command:

1. To act as technical adviser to the commanding general, or his designated assistant, on all matters pertaining to surveillance and safety in connection with ammunition, ammunition components, and explosives.

2. To make inspections of ammunition, ammunition components, and explosives (including explosives for submarine mines) and storage thereof, as required at posts, camps, and stations, under the jurisdiction of the service command; to record and report on conditions encountered, giving lot number and quantity.

3. To supervise allocation and preparation of ammunition for training activities and expenditures.

4. To attend seacoast artillery target practices and maneuvers, wherever possible, and supervise taking of cannon pressures where required.

5. To supervise maintenance, modification, and renovation of ammunition and components in accordance with instructions from the Chief of Ordnance.

6. To investigate malfunctions of, and accidents attributable to, ammunition, ammunition components, and explosives.

7. To maintain file of drawings, specifications, and regulations pertaining to ammunition, ammunition components, and explosives.

8. To initiate reports and maintain files to cover above activities.

At an Overseas Department. The following duties are suggested as being within the capabilities and qualifications of the ammunition inspectors assigned to duty in an overseas department:

1. Duties are, in general, similar to those performed at both depot and service command with increased responsibility for maintenance, modification, loading, and renovation of ammunition, ammunition components, and explosives, and greater control over movement and issue within the department.

2. To investigate causes of damage to, or deterioration of ammunition, ammunition components, and explosives.

3. To maintain record of magazine space available and act as consultant in connection with the location and construction of new magazines.

4. To act as ordnance representative on board Army transports when loading or unloading ammunition, ammunition components, or explosives through department port facilities.

5. To inspect ammunition, ammunition components, and explosives for condition and serviceability upon arrival.

At a Port of Embarkation. The following duties are suggested as being within the capabilities and qualifications of the ammunition inspectors assigned to duty at ports of embarkation:

1. To act as technical adviser to the port ordnance officer on all matters pertaining to, and facilities used in connection with, the receipt, handling, storage, movement, stowing, loading, and bracing of ammunition, ammunition components, and explosives.

2. To inspect condition and serviceability of ammunition, ammunition components, and explosives upon receipt at, or movement through, the port facilities.

3. To inspect all transportation facilities, including freight cars, trucks, ships, etc., for suitability and compliance with existing instructions and regulations.

4. To inspect all incoming shipments for compliance with instructions contained in the Ordnance Safety Manual, Ordnance Department Safety Bulletins, I.C.C. regulations and Bureau of Explosives publications, state, municipal, and port regulations.

5. To act as ordnance representative aboard Army transports or commercial vessels when loading or unloading ammunition, ammunition components, and explosives through the port facilities.

6. To maintain such records as may be required to assure positive identification and control of movement by type and lot number of ammunition, ammunition components, and explosives.

At the Headquarters Army Air Forces. The following duties are suggested as being within the capabilities and qualifications of the ammunition inspector assigned to duty at the Headquarters Army Air Forces:

1. To act as technical adviser to the air ordnance officer on all matters relating to the surveillance, storage and safety of ammunition, ammunition components, and explosives.

2. To make periodic trips to the numbered air forces and Army Air Force nontactical commands relative to matters pertaining to the storage, maintenance, and surveillance of ammunition items required by the Army Air Forces. To inspect ordnance storage areas and ammunition stored therein at various installations under the numbered air forces or command.

3. To advise the air forces and commands of special inspections or tests required on ammunition items as determined by the Office of the Chief of Ordnance or the Air Ordnance Office.

4. To assist and guide junior ammunition inspectors assigned to the Army Air Forces, and to maintain a record of their progress and ability for forwarding to the Office of the Chief of Ordnance in accordance with existing instructions.

5. To perform such additional duties as may be assigned by the air ordnance officer.

At a Numbered Air Force or Army Air Force Nontactical Command. The following duties are suggested as being within the capabilities and qualifications of the ammunition inspector assigned to duty at a numbered air force or Army Air Force nontactical command:

1. Acts as technical adviser to the ordnance officer on all matters pertaining to the surveillance, storage, and safety of ammunition, ammunition components, and explosives.

2. Makes periodic inspections of ammunition, ammunition components, explosives, and storage thereof, at air bases, flying schools, and other stations under jurisdiction of the Army Air Forces, as required by TM 9-1900, chapter 3, section III, "Inspection and Surveillance"; recommends necessary action to correct any unsatisfactory conditions noted.

3. Reviews reports received from the field, such as malfunction reports and ammunition condition reports; conducts investigations when required, and forwards complete reports with recommended action to the Air Ordnance Office, Headquarters Army Air Forces.

4. In instances where field modifications or renovation of ammunition items is authorized by higher authority, recommends methods to be employed from a safety standpoint and supervises the work where feasible.

5. Conducts special inspections, tests, and investigations relative to ammunition items used by the Army Air Forces in accordance with instructions from the Air Ordnance Office.

6. Performs such additional duties as may be assigned by the ordnance officer.

SURVEILLANCE LABORATORIES, WORKSHOPS, AND EQUIPMENT.

Surveillance laboratories have been established at certain of the older depots and overseas departments; these laboratories were usually provided with the required equipment for performing the 65.5 C and 135 C heat tests and with such accessory apparatus needed for analytical or other prescribed tests of smokeless powder and explosives. In addition, these depots normally have a building set aside for a surveillance workshop, wherein all surveillance activities pertaining to disassembly or assembly, observation, inspection, and investigation of ammunition and ammunition components are carried out. The newer establishments are not being provided with a laboratory but are provided with a modern inspector's workshop (drawing 19-3-559, file 43), wherein the surveillance activities in connection with routine and special inspections and investigations may be performed efficiently and safely.

Each depot or department is required to be equipped with all tools (regular, special, and safety) and equipment necessary to perform all surveillance activities. The equipment is usually manufactured locally or procured from commercial sources and modified, where necessary, to fit the requirements of the operation, although certain items of equipment, such as those for disassembly and assembly, scales, etc., have been standardized and are procured through ordnance channels.

Safety tools are required where the use of tools made of steel or iron would create hazards, beyond the design of the ammunition or ammunition components, by introducing the possibility of sparking. Safety tools are usually nonferrous, being mostly made of wood, aluminum, brass, bronze, copper, fiber, or commercial beryllium compositions retaining, under normal usage, the nonsparking property, but designed to give additional strength. The recognition of the safety tool principle in commercial industry has resulted in the design of many tools which are readily adaptable to ordnance requirements. The ammunition workshop should be equipped with the types of nonsparking tools required for the proper performance of all surveillance activities.

SURVEILLANCE INSPECTIONS AND TESTS.

Surveillance inspections and tests are performed primarily for the purpose of detecting any increase in the normally expected rate of deterioration, the current condition or degree of serviceability, and any increase in the normal hazards of the ammunition, ammunition components, or explosives under observation. These inspections and tests are in two groups, those usually performed in the field at the place of storage and those performed at a ballistic or chemical laboratory. All are performed in accordance with instructions issued by the Chief of Ordnance.

Routine surveillance inspections and tests performed in the field are limited in scope by the requirements for accuracy and equipment. A detailed description of these tests as regards requirements, equipment and methods will be found in other pertinent sections of this bulletin. In general the inspections and tests in this group comprise the following:

1. The N/10 methyl violet paper test of bulk smokeless powder.

2. The N/10 methyl violet paper test and inspection of smokeless powder propelling charges, and air test of certain types of containers.

3. The annual surveillance inspection of separate loading projectiles, fixed and semifixed ammunition, trench mortar ammunition, grenades, bombs, ammunition components, pyrotechnics, small-arms

ammunition, bulk explosives, black powder charges, black ammunition, mines, and demolition materiel:

4. The semiannual inspection of chemical ammunition.

5. The monthly magazine inspection, including the magazines and surrounding area, and the storage of ammunition, ammunition components, and explosives.

6. Such additional inspections and tests as may be required as a result of those listed above.

7. The semiannual visual inspection and the annual electrical test of the lightning protection system. NOTE: One of the semiannual visual inspections is normally performed at the time of the annual electrical test.

8. Inspections of incoming and outgoing shipments.

9. Inspections of magazine area activities.

10. Such additional routine-type tests and inspections as may be prescribed by the Chief of Ordnance or necessitated by local conditions.

Special tests, observations, inspection, and investigations may be prescribed by the Chief of Ordnance, as required. These may necessitate disassembly of complete rounds of ammunition or components. Complete and detailed instructions as to object, method, and special equipment required, will be furnished in each case.

Special ballistic and functioning tests and investigations on ammunition, or ammunition components may be ordered by the Chief of Ordnance, as required. These tests or investigations are usually performed at Aberdeen Proving Ground, under the supervision of Ballistic Research Laboratory personnel, and are regulated by pertinent Ordnance Surveillance Manual pamphlets of the numbered series, as to operations, classification, and grading.

Special chemical tests or investigations may be prescribed by the Chief of Ordnance for ammunition, ammunition components, and explosives. These are usually performed at the Picatinny Arsenal in accordance with standard arsenal procedure.

Chapter 3

Surveillance Records and Reports

ROUTINE RECORDS, DEPOT.

The routine surveillance records normally installed and maintained by the ammunition inspector are those which may be readily established and maintained by routine information gathered from local sources and generally consist of:

1. Surveillance data card file, which includes a copy of the data card for each lot of ammunition, ammunition components, and explosives in storage, filed according to caliber or type. This file is a valuable reference and source of information in connection with both routine and special inspections and investigations of lots under examination. The contained information is in convenient form and is, ballistically, the foundation of the technical history of the lot. The data cards may be received as inclosures to shipping documents covering incoming shipments, or may be secured, in certain instances, from standard packages. Should it be impossible to secure a copy of a data card for a lot in this manner, the required data may be secured from the Office of the Chief of Ordnance upon application. Any variation or error noted in data cards as a result of surveillance, or other activity should be reported to the Chief of Ordnance and to the War Reserve Surveillance Section, Aberdeen Proving Ground, Maryland, in order that the master files may be corrected. Should a lot become exhausted, the data card should be retained in a dead file for a period of one year for possible future reference. If the shipment is made to another depot, the data card will be forwarded to that depot for inclusion in the data card file there.

2. Depot surveillance record file which is compiled on O.O. Form No. 5999, from data taken from the lot data card in conjunction with inspection upon arrival or storage. The front of the card contains space upon which are entered the nomenclature, manufacture, lot, and all available pertinent data concerning components, finish, date of arrival, number of units received, etc. All possible information will be entered in the spaces provided. The reverse side of the card is used to record results of all inspections, tests, observation, investigations, or unusual occurrences pertaining to the lot, by date and name of person performing the operation. The data is taken from the various local forms used as worksheets in connection with the performance of the operations involved. A notation as to suspension of the lot, when such action has been ordered by the Chief of Ordnance, should be noted properly on this record, together with file number of authority for such action. This record is a continuation of the technical history of the lot and every effort should be made to maintain it properly. The information contained in this file may be readily utilized in connection with the submission of estimates to cover maintenance, reconditioning, or renovation activities. Sample of Form 5999 is shown in figure 329.

3. Maximum and minimum temperature records are taken and recorded to cover the temperature range of various representative types of magazines and the atmospheric temperature in the shade. These readings may be secured by means of Sixe's type of recording thermometers, and the information, together with a record of any abnormal meteorological conditions, forms an additional and invaluable

part of the technical history of the lot of ammunition, ammunition component, or explosive, and should be so included when compiling the records.

4. Such additional records as may be required to meet local conditions of a routine nature.

SPECIAL RECORDS, DEPOT.

The special surveillance records normally installed and maintained by the ammunition inspector are those which are established and maintained as the result of information required for, or gained from, local sources, and are based on special observations, inspections, tests, and investigations prescribed by the Chief of Ordnance, or necessitated by local conditions of climate or storage. They generally consist of the following:

1. N/10 methyl violet paper test and inspection records compiled as a result of the performance of this test and inspection on bulk smokeless powder, and on smokeless powder propelling charges, in accordance with instructions of the Chief of Ordnance as contained in OFSB 3-13, and changes thereto, and special instructions contained in correspondence on the same subject. This test, plus the air test of certain types of propelling charge containers, conducted in accordance with instructions contained in paragraph 100 *a* of the Ordnance Safety Manual, is the basis of much valuable information applicable to the technical history of the lot involved. In addition to the required report, a copy of which is considered essential for this record, a brief notation of test results should be noted on the depot surveillance record card for the individual lot.

2. Annual surveillance inspections and tests of all types of ammunition, ammunition components, and explosives (or semiannual in the case of chemical ammunition), will ordinarily be recorded on local forms. Data concerning the propelling charges of fixed and semifixed ammunition will be recorded on O.O. Form 5990-A. The resulting data should be compiled and recorded on the depot surveillance record card pertaining to the lot in question and become a part of the technical history of the lot. Sample of Form 5990-A is shown in figure 330.

3. Special surveillance inspections, tests, and investigations prescribed by the Chief of Ordnance will be recorded on local forms in order that the required information may be secured. The desired data will be compiled and entered, when applicable, on the depot surveillance record card, pertaining to the lot in question, and as such, will become a portion of the technical history of the lot.

4. Additional surveillance inspections, tests, and investigations, may be required to secure desired data, or as the result of unfavorable nonstandard conditions in connection with all ammunition activities.

SOUTHEASTERN ORDNANCE DEPOT
MAINESHIRE, NEW PENNSYLFORNIA

O. O. Form 5999

DEPOT SURVEILLANCE RECORD

A.I.C. No. ____

Item: Grenade, Hand, Anti-aircraft, Mk. 103 M1A2, w/fuze, igniting, Mk. 116M2A1 (Dwg. 82-0-1111) (Standard nomenclature) Mfr. D. C. O. P. (Or loading company) Lot 9-13

Date received 15 August 1942 Quantity 1976 Magazine A 101

Packed 24 per box in accordance with Dwg. 76-16-1111

Painted and Marked in accordance with Dwg. 82-0-1111

Grade 1 Class 4 Smokeless Powder Mfr. Herc. Lot 79994 of 1943

Filler E.C. Smokeless Powder With or without Components with fuze

With or without Adapter and Booster w/o Fuzed or unfuzed (if fuzed show mark or model number) Mk. 116M2A1, Dwg. 82-1-1111

Type of Base - - - Type of Band - - -

Type of Closing Plug Fuze Protective Coating in accordance with Dwg. 82-0-1111

Remarks packed 1 per fiber container M980; 24 containers per box. See Dwg. 20-4-1111

RA PD 64472

Figure 329 — Sample O.O. Form 5999—Front

DATE	BY WHOM	RECORD OF INSPECTIONS
16 Aug. 42	J.A.D., Jr.	Percentage inspection of incoming shipment; 72 grenades in 3 boxes inspected; no defects; resealed as original packing. CONDITION 1
30 June 43	J.A.D., Jr.	Annual surveillance inspection; 96 grenades in 4 representative boxes; slight spot of corrosion on head of one fuze due to handling during assembly; otherwise no defects visible; sealing good condition; resealed as original package. CONDITION 1

RA PD 64473

Figure 330 — Sample O.O. Form 5999—Reverse

These may be as authorized by the commanding officer, based on requirements of the situation encountered. Ordinarily they will be of a percentage nature in order to secure sufficient data upon which a report of the situation encountered may be forwarded to the Chief of Ordnance for decision as to final action to be taken. The data gathered in connection with this type of inspection will be recorded on the depot surveillance record card pertaining to the lot in question and, as such, become a portion of the technical history of the lot.

5. A record should be maintained of all methods, facilities, and necessary local safety regulations, employed in connection with all maintenance, reconditioning, renovation, assembling and loading, salvaging, and destruction operations involving ammunition, ammunition components, and explosives. This record should include, where practicable, pictures and sketches of special tools, equipment and methods for future reference.

6. Safety inspections made of all operations involving ammunition, ammunition components, and explosives, should be made a matter of record. This record should include reports of safety violations, where found, together with recommendations for correction and record of action taken.

7. A record index and file should be maintained of all War Department drawings, specifications, and publications covering ammunition, ammunition components, explosives, and methods of packing, shipping, and storing same.

ROUTINE REPORTS, DEPOT.

The routine surveillance reports normally prepared by the ammunition inspector are those which are submitted to cover all routine activities in connection with ammunition, ammunition components, and explosives and generally consist of the following:

1. Monthly report of activities which will be prepared as of the last day of each month by the ammunition inspector and will cover all activities of the surveillance force during the month. This report should be made in narrative form and contain a brief statement concerning each activity together with such pertinent comment on progress, difficulties encountered, corrective action taken, and independent expression of opinion, especially on technical matters, as may be required to present the complete picture of the status of surveillance activities. The report should contain a running record of all ammunition inspector personnel changes during the period covered; all uncorrected violations of safety and storage regulations; and, as inclosures, a chart covering the daily maximum and minimum temperature readings of the atmospheric temperature and of a representative magazine of each type. The report will be addressed to the Chief of Ordnance, through the commanding officer, who will forward it to the Chief of Ordnance by indorsement.

O.O. Form 5990-A C.B. Reg. No. 04-339-FA-OC

TESTS OF SMOKELESS POWDER

Cal. 3"AA Gun Shrapnel Mfr. DP Powder lot Pyro X-2616-A/18

Bulk .... Charges .... Fixed amm. .... Lot No. P.A. 1354-1

DATE	65.5° C. DAYS
July 1941	198

VISUALLY DETERIORATED GRAINS

Sample	%	Sample	%
1 -	.00	7 -	
2 -	.00	8 -	
3 -	.00	9 -	
4 -		10 -	
5 -		11 -	
6 -		12 -	

Signed [illegible signature]
Ammunition Inspector.

Depot Hawaiian Ordnance Average: .00

Sample of report submitted on O.O. Form 5990-A, covering field surveillance inspection of fixed ammunition.

O.O. Form 5990-A C.B. Reg. No. 07-343-FA-OC

TESTS OF SMOKELESS POWDER

Cal. 3" TM Mfr. Herc. Powder lot 4586-1942 Cut 226

Bulk .... Charges .... Fixed amm. .... Lot No. ....

DATE	65.5° C. DAYS
5/10/43	198

VISUALLY DETERIORATED GRAINS

Sample	%	Sample	%
1 -		7 -	
2 -		8 -	
3 -		9 -	
4 -		10 -	
5 -		11 -	
6 -		12 -	

Signed W. T. Ingraham
Ammunition Inspector.

Depot Picatinny Arsenal Average:

Sample of report submitted on O.O. Form 5990-A, covering Arsenal report of 65.5° C. test results.

RA PD 64474A

Figure 331 — Sample Reports Submitted on O.O. Form 5990A

2. The semiannual report of progress and development of ammunition inspectors is submitted in the original only, with all from one establishment as inclosures to a single cover letter, as of the last of January, and July of each year, and on a form which was specifically designed to cover the important points in the development of all well-trained ammunition inspectors. The report is prepared by the ammunition inspector in charge to cover each ammunition inspector under his supervision and submitted through the commanding officer for review, comment, and recommendation, in indorsing the report to the Chief of Ordnance. The report covering the ammunition inspector in charge is prepared by direction of the commanding officer and forwarded at the same time. Sample of desired type of report is shown in figure 332.

3. Report of N/10 methyl violet paper test of bulk smokeless powder and separate loading propelling charges will be submitted in accordance with instructions of OFSB 3-13, changes thereto, and special instructions contained in correspondence on the same subject.

4. Report of annual surveillance inspection of propellent charges in fixed and semifixed ammunition will be submitted on O.O. Form No. 5990-A.

5. Report of monthly magazine and storage inspection will be submitted to the commanding officer to cover all violations of safety regulations, area, building, storage, and material deficiencies affecting ammunition, ammunition components, and explosives; together with recommendations for correction, or statement of corrective action inaugurated or completed. This report is usually in brief narrative form and covers defects only.

SPECIAL REPORTS, DEPOT.

The special surveillance reports normally prepared by the ammunition inspector are those which are submitted to cover special activities in connection with ammunition, ammunition components, and explosives, and normally consist of the following:

1. Report in narrative form prepared upon the completion of all activities in connection with maintenance, reconditioning, renovation, assembling, loading, and salvaging and destruction operations involving ammunition, ammunition components, and explosives. This report should cover all pertinent phases of the operations, including pictures and sketches where practicable; and special emphasis should be given to nonstandard materiel encountered, and local safety regulations enforced during the operations. Facilities devised locally, and methods of operation, together with such comments of a technical nature as are of general interest, should be included.

2. Reports of renovation, assembling, or loading activities will be accompanied by an ammunition lot description sheet for each lot of ammunition involved.

3. Reports of special inspections, observations, tests, and investigations of ammunition, ammunition components, and explosives performed in accordance with instructions of the Chief of Ordnance may include, in addition to the data called for, comments, or such additional information gathered during the operations that may pertain to the objective, or aid in clarifying the results obtained.

4. Ammunition condition reports submitted to cover unserviceable ammunition, ammunition components, and explosives in accordance with existing regulations.

5. Report of acceptance test, covering lots of ammunition loaded or assembled locally, and requiring local acceptance test, prepared and submitted as directed by the Chief of Ordnance.

6. Special activities reports to the Chief of Ordnance may be submitted to transmit data specifically requested, or as necessitated by special local occurrences, such as damage from natural phenomena, receipt of damaged items, dangerous conditions, etc. These reports are usually in letter form, either basis or by indorsement, although other forms may be used if deemed essential to presentation of the data.

RECORDS, SERVICE COMMAND AND DEPARTMENTAL.

Records pertaining to ammunition, ammunition components, and explosives in a service command or overseas department may, in general, be divided into three categories, namely:

1. Service command or departmental.
2. Depot, or reserve storage area.
3. Post, camp or station.

NOTE: These three classes are generally separate, the service command or department records being maintained in service command or department headquarters; the depot records in the administrative or the magazine section office of the depot; and the post, camp or station records, which may be considered as including all appropriate records pertaining to items in the hands of organizations or in central storage at that location, in the local ordnance office. In most instances the information contained in the records of categories (2) and (3), above, are the records on which those in category (1) are based.

Local conditions may require special forms or possible adaptations of standard forms and types of records in service commands and departments. The standard records normally maintained include the following:

1. Surveillance data card file.
2. Depot surveillance record file.
3. N/10 methyl violet paper test and inspection records.
4. Annual surveillance inspection of ammunition, ammunition

STATION: SOUTHEASTERN ORDNANCE DEPOT
MAINESHIRE, NEW PENNSYLFORNIA

C.B. Reg. No.
07-176-FA-OC

FILE.201 Doe, John A., Jr. DATE 31 July 1943

SUBJECT: Report of Ammunition Inspector's Progress and Development.

To: Chief of Ordnance, War Department, Washington, D.C.
Attention: SPOFA - Surveillance Section

THRU: Commanding Officer
(Name of Ordnance Officer Reviewing Report)

1. Report is hereby submitted to cover the progress and development of John A. Doe, Jr., Ammunition Inspector, CAF-6, $2300 p/a
(Name, Grade, and Salary)

for the period from 30 April to 31 July, 1943.

a Inspector's present assignment of duty Varying during report period - covered incoming shipments, storage operations, reconditioning operations, and such other minor duties as assigned by the supervising Inspector.

b. Indicate degree of: (Use words Excellent, Good, Medium, or Unsatisfactory)

(1) Familiarity with assigned duties	Good
(2) Technical knowledge of Safety Regulations	Good
(3) Technical knowledge of Surveillance	Good
(4) Practical knowledge of activities	Excellent

c To what degree is the Inspector: (Use words Excellent, Good, Medium, or Unsatisfactory)

(1) Dependable	Excellent
(2) Observant	Good
(3) Able to make observations or suggestions without causing undue friction	Good
(4) Able to translate written instructions, blue-print data, etc., to practical application.	Good

d. To what degree does the Inspector display: (Use words Excellent, Good, Medium, or Unsatisfactory)

(1) Initiative	Medium
(2) Ability to give orders and have them executed.	Good
(3) Practical Originality	Good
(4) Ability to absorb training and knowledge	Good
(5) Cooperation with colleagues	Excellent
(6) Interest in his personal appearance	Good

NOTE: Selective Service Status - - 4-F

(Over)

RA PD 64475A

Figure 332 — Sample Report Submitted on Form 42-10471—Front

e. Is he considered capable of performing the duties of the next higher grade (answer "yes" or "no"). No

f. Pertinent comments or remarks not covered above or in explanation of ratings made above.

Mr. Doe has the makings of an excellent inspector; he lacks initiative, mainly because of lack of faith in his judgement. He is being given the training necessary to correct this fault. Mr. Doe was promoted to Grade CAF-6 on 1 July 1943 and will not be eligible for additional promotion until 1 January 1944, providing he corrects the tendency commented upon above.

Prepared by:

Assoc. Head Ammunition Inspector

APPROVED:

Col., Ord. Dept.
Commanding

RA PD 64476

Figure 333 — Sample Report Submitted on Form 42-10471—Reverse

components, and explosives, including mine explosives stored at coast artillery posts.

5. Safety inspection records.

6. Record index and file of drawings, specifications, and publications pertaining to ammunition, ammunition components, and explosives.

7. Records of functioning and performance in training on function firings.

8. In addition, such special records as may be required to assure constant accurate references for preparation of reports, submission of requisitions, or establishment of allowances within the jurisdiction of the service command or department.

REPORTS, SERVICE COMMAND AND DEPARTMENTAL.

The reports normally submitted by the ammunition inspector include those described for Routine Reports, Depot, where applicable; and Special Reports, Depot; the annual report of inspection of explosives for submarine mines, including both TNT and fuze caps, will be submitted on O.O. Form 7452 as directed in paragraph 56 *g* of TM 4-220.

REPORTS, ARMY AIR FORCES.

The reports submitted by the Army Air Forces, as prepared by the ammunition inspector, to the Office of the Chief of Ordnance, through channels, will include those described for Routine Reports, Depot; Special Reports, Depot, where applicable; and reports as required by the air ordnance officer, Army Air Forces.

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D—Cont'd

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P—Cont'd

S—Cont'd

S—Cont'd

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